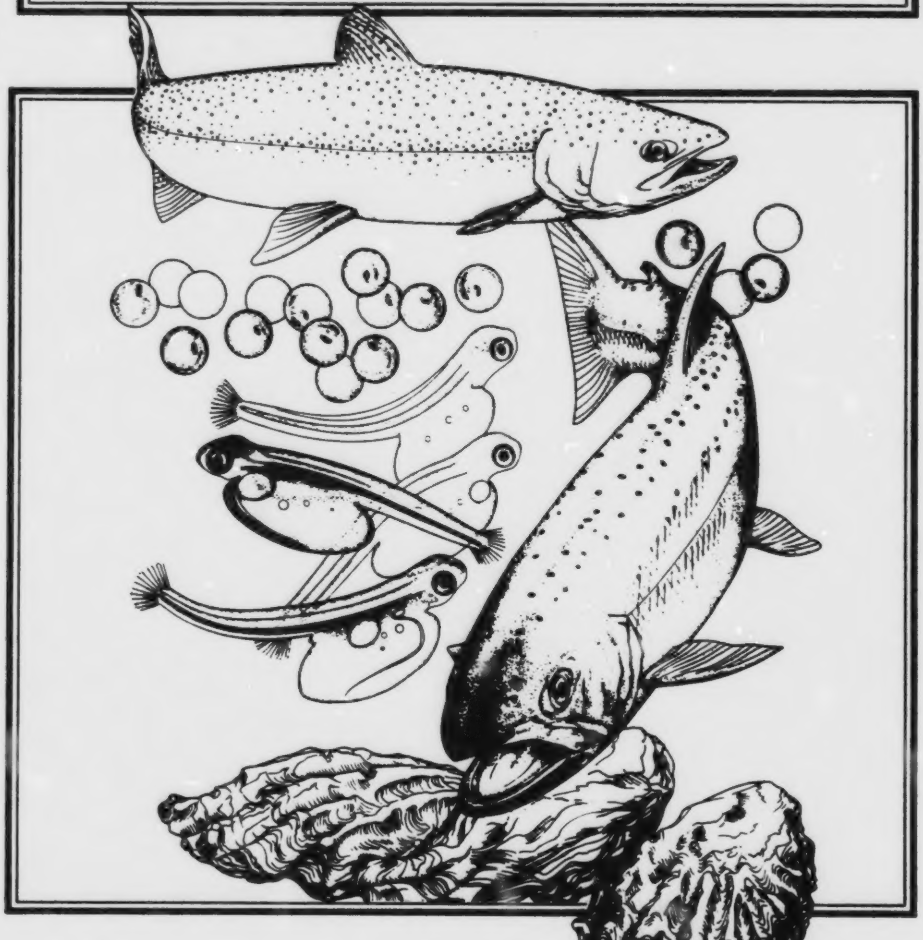
Aquaculture Industry Development Report

Proceedings of the 1990 Manila Clam Culture Workshop



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Held at Parksville,
British Columbia

October 18-19, 1990

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PROCEEDINGS OF THE 1990 MANILA CLAM CULTURE WORKSHOP

Workshop Sponsored and Hosted October 18-19, 1990 by

the Ministry of Agriculture and Fisheries

Proceedings Prepared and Edited By :

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December 5, 1990

The Ministry of Agriculture and Fisheries is the lead agency for aquacultural activities in British Columbia. We hosted the Manila Clam Culture Workshop in 1988 to address questions and concerns of the shellfish industry, the public, and government agencies regarding the possibility for developing Manila clam farming in British Columbia. The economic and technical feasibility appeared sufficiently attractive that industry and government began to work more actively on resolving technical and administrative constraints to this industry.

Two years have now passed since the first workshop, and in response to the growing enthusiasm for this budding industry, the ministry hosted this second Manila Clam Culture Workshop to evaluate the developments that have occurred. The response from the participating parties at the workshop showed that an industry is emerging, and that future progress will largely depend on the development and application of sound farming practices, supported with progressive policies for foreshore use.

The Ministry of Agriculture and Fisheries may be contacted for further information pertaining to clam farming topics such as permits, siting, production technology, and economic evaluation. We shall strive to foster the continued growth and development of this industry in British Columbia.

Mr. Jim Anderson
Director
Aquaculture and Commercial Fisheries Branch
Ministry of Agriculture and Fisheries

Editors Preface

The proceedings of the 1990 Manila Clam Culture Workshop have been transcribed, edited and compiled into this publication. The majority of the presentations are verbatim and each presenter has edited their presentation to ensure its accuracy. All contributing parties made this workshop a success by their willingness to share their expertise, especially the large contingent from south of the border. The proceedings of this second clam culture workshop builds upon the issues and concerns addressed at the first clam workshop in 1988, thus ensuring our fledgling industry has a continuity of information on which to grow. We hope you find that this document provides a comprehensive synopsis of the information presented.

Mr. W.E. Lorne Clayton
Mr. T.A. Broadley
Mr. W.G Roland

Acknowledgements

A publication such as this requires the contributions of many people, not the least of which are the participants, speakers and organizers. We would like to take this opportunity to thank everyone affiliated with this workshop and subsequent publication of this proceedings.

Funding for the workshop and proceedings was made available from the Ministry of Agriculture and Fisheries. Mr. Jim Anderson, Mr. Jim Fralick and Dr. Al Castledine, of the Aquaculture and Commercial Fisheries Branch, were enthusiastic supporters of the workshop. Mr. Bill Roland, Ministry of Agriculture and Fisheries, and Ms. Christine Hodgson, North Island College, organized the venue and speakers for the workshop. The staff of Island Hall, Parksville, B.C. provided a hospitable setting for the workshop. The participants at the workshop were an informative and inquisitive audience. The speakers, who are the key to the success of such a workshop, willingly shared their experience, knowledge and views and also put up with our editing demands and time deadlines.

To all of these people we express our sincere appreciation for their valued contribution to the 1990 Manila Clam Culture Workshop.

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WORKSHOP SUMMARY AND RECOMMENDATIONS

Mr. W.E. Lorne Clayton and
Mr. T.A. Broadley

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Synopsis of the Present Clam Industry in British Columbia

During the two years since the first clam culture workshop the clam fishing industry has gone through changes which have, and will continue to have, impacts on the development of the clam culture industry in this province.

As a result of continued high prices for the Manila clam, fishing pressures have remained strong and landings have decreased over 29% (Harbo, pers. comm.). It is suggested that this decrease has, in some cases, driven the price of Manila clams above the level that some markets are prepared to pay, resulting in a decline in markets for some producers. This has also allowed a competing product, the New Zealand cockle, a niche in the market in the United States as a replacement for the Manila clam.

Governments have begun the process of developing policy and agreements with which to regulate the development of clam farming. This includes the development of: a Memorandum of Understanding (M.O.U.) between the provincial and federal governments; Letters of Understanding (L.O.U.) between the provincial Ministry of Agriculture and Fisheries (M.A.F.) and the federal Department of Fisheries and Oceans (D.F.O.); and, between the provincial Ministries of Crown Lands and M.A.F. which more precisely document responsibilities in regard to the regulation of the clam culture industry.

Research is being conducted in various aspects of clam farming as a result of recommendations made at the first clam culture workshop and from the B.C. Aquaculture Research and Development Council. Principal funding agencies have been the Science Council of B.C. and M.A.F..

In retrospect, much has been accomplished during the past two years and we appear well on our way to structuring a new industry for British Columbia. We believe that the information, problem identification and recommendations which have been produced as a result of the second Manila clam culture workshop will add to this process.

Problem Identification

Upon summation of the workshop, it was possible to identify problems which could negatively affect the development oof the clam farming infrastructure. While problems still exist in the clam fishery the following relate to clam culture except where the impact of the fishery may be relevant to a clam farm. The following problems were identified as the most pertinent:

- due to an increasing interest by industry in converting tenures to include clam culture, there exists a backlog of paperwork in applicable government offices. It is expected that the backlog may exist for between 6-12 months;
- under provincial policy, the only allowable entry into clam farming is through the conversion of existing tenures to clam culture. This policy has alienated the clam fisherman and others who may be interested in becoming involved in this new industry;
- the continued lack of information on natural recruitment and carrying capacity of beaches has led to site specific problems with respect to minimum seeding policies which may affect seed survival and growth rate in culture plots;
- inadequate resources for monitoring biotoxins, biological and other contaminants, which negatively affect the continuity of supply of product to the market, has jeopardized the success of some businesses;
- the industry suffers from a "poor quality" stigma which must be addressed. More work is required on quality control and product safety;
- resources are lacking for the continued monitoring of diligent use on existing industry shellfish tenures which has unnecessarily tied up valuable land resources;
- industry members have not made adequate diligent use of existing tenures which negatively impacts upon the development of appropriate government policies for lease management and public perception;
- the practicality of clam and oyster polyculture has not been adequately addressed in specific regards to management plan expectations, diligent use policy and minimum seeding requirements; and,
- some federal policies, especially those which deal with utilization of natural seed for enhancement and the moving of seed on a tenure, remain unclear. This puts the onus of dealing with regulatory agencies on the individual grower.

Recommendations

Through analysing the workshop proceedings and discussions with industry members and government officials, a series of recommendations have been developed. To further promote the development of an economically and technically feasible clam culture industry in British Columbia, the following recommendations are proposed:

Recommendations to Government

It is recommended that governments:

- in association with industry, continue to develop regulations which realistically define clam culture, the overall purpose of which is to streamline and stabilize the development of a successful clam culture industry in British Columbia;
- be willing to allocate additional select intertidal resources for clam culture that are capable of supporting increased clam production;
- allocate the resources necessary (monetary and personnel) to adequately address the problem of transient diggers on clam farm leases;
- assist industry in establishing production and management plans for the planning and development of economically viable clam culture consistent with the agreed definition of clam culture;
- provide increased resources (monetary and personnel) with respect to the monitoring and testing of biotoxins, disease and sanitary shellfish water quality which will support the development of a clam culture industry in British Columbia;
- establish policies and regulations that allow for the further development of natural and controlled depuration of shellfish;
- support economic studies in order to determine the long term viability of Manila clam culture in British Columbia;
- sponsor regular clam culture workshops to review current progress and to assist in the planning and development of a clam culture industry;
- maintain an active "research priority" list of studies which will contribute to our knowledge of the clam farming industry in B.C.; and,
- provide the resources to adequately monitor the diligent use of clam farm tenures.

Recommendations to Industry

It is recommended that industry members:

- continue to work with government in developing a regulatory infrastructure which supports the continuing development of the clam farming industry in British Columbia;
- assist in determining and priorizing research needs for the ongoing development of a viable clam culture industry;
- work cooperatively with other industry members and governments in carrying out applicable studies to determine the economic feasibility of clam culture;
- work cooperatively in developing a "quality control " program to assure the finest product reaches the consumer;
- provide accurate statistics to the monitoring bodies to assist in recording the progress in industry development; and,
- utilize crown land in an honest and diligent manner in order to justify the alienation of public resources.

WELCOME AND INTRODUCTION

Mr. Bill Roland

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Welcome to the second Manila clam culture workshop. The first workshop was held two years ago and it addressed the possibilities of clam culture. Today we want to talk about the current status of clam culture.

I would like to highlight some recent developments and also discuss the issue of common law fisheries and property rights in aquaculture. Over the past two years there have been several developments regarding clam culture that are noteworthy.

1. Landed clam prices have been good and stocks are in short supply.
2. Numerous oyster growers are attempting to culture clams.
3. Because in British Columbia we do not have the experience and knowledge with which to confidently base development of a profitable clam farming enterprise, there have been a number of investigations started to provide information about clam production from husbandry and cost of production points of view. This will be one of the major focuses of this workshop.
4. Clam culture has a definition, somewhat based on regulations, as an attempt to increase production of an intertidal lease based on a production schedule that includes seeding of clams at a minimum of 200 per square meter. Generally the lease will already be an existing oyster tenure.
5. Property rights to the clams produced or naturally found on the lease, as of this moment, are not secure but an agreement has been reached between the provincial and federal governments which will make cultured clams private property.
6. Problems with the clam fishery interfering with oyster stocks has been somewhat alleviated by allowing oyster farmers to file harvest schedules which give them control of fishing activities. This schedule is subject to conservation and other types of closures.

I would now like to discuss, at least as I see it, some of the history behind the current management situation of clam culture. As an analogy, think of clam farming as one part of a large house of resource or fisheries management that was initially built about one thousand years ago. Over time the shape of the house has changed and it will continue to change to meet the needs and expectations of the inhabitants.

Prior to 1215 AD the crown granted fishing rights and because this practice caused friction, these rights were taken away by the Magna Carta. The Magna Carta essentially made marine fisheries, not inland fisheries, a common property resource. Since the Magna Carta, through various legislation and litigation, there has been a slow trend back to giving some fishing rights to individuals.

The British North America (B.N.A.) Act in 1867 gave the federal government the exclusive legislative authority over the sea coast and inland fishery, however, the B.N.A. Act gave the provinces jurisdiction over land and property. Since the Magna Carta tied the fisheries to the land, a subsequent court case gave the right to dispose of inland fisheries through licences, etc. to the provinces. This started initially in Ontario and subsequently the federal government has more or less given control of the inland fishery to the provinces. This control, however, is still under their conservation jurisdiction. Another court case has given the ownership of all tidal land, bays and inlets between Vancouver Island and the mainland and between the Queen Charlotte Islands and the mainland to the province. The fisheries are still the jurisdiction of the federal government for conservation and allocation.

Since the early 1970's some fisheries in Canada are limited entry meaning that the licence holder has the right to compete to catch a quota of fish that is set by the management agency and that quota varies from year to year. The right to fish is something like a property right but the fish only become property once caught.

More recently Canada and other countries have moved toward individual vessel quotas. This gives the fisherman the right to catch a fixed amount of stock without competition, at least among the other quota holders. The quota can vary from year to year. Mobile fish are not property until caught and probably cannot be property because of the difficulty in identifying specific fish as property. However, clams are relatively stationary and can be associated with the land and lend themselves more toward a private property designation.

The Fisheries Act provides for leases and licences that give the holder the exclusive rights to the oysters produced or found on the beds within the tenure. Clams, abalone, etc. are not mentioned in this act which I suspect restricts aquaculture opportunities, for other than oysters, to off-bottom and land based culture except through other arrangements. The Letter of Understanding on clam culture between the provincial and federal governments will be a less formal arrangement that will give property rights to clams found on clam tenures.

I think there is, at least, a slow move towards giving some property rights to individuals to more efficiently manage fish stocks. Management concerns primarily address stock conservation and sustainable yield but they are coupled with concerns for social and economic issues such as employment and over investment in fishing gear.

The key concepts involved in granting property rights to wild clams in culture are: the tradition of fisheries to be seen as common property; the federal-provincial jurisdiction over clams in tidal waters; and, the value that can be derived from clam culture above what it would be worth in the fishery. The increased economic, employment values and management ease that can generally be realized from aquaculture are fairly obvious and the profits can go to the farmer or can be transferred through lease fees, etc. back to the coffers of the land lord which in this case can be the government or society, in general.

The framework we are working within is one comprised of societies traditional values regarding ownership of fisheries, the tradition of free enterprise and the potential for economic growth. Management concerns, problems and increasing expenses borne by the regulatory agencies are caused by people wanting to utilize the fishery and to enhance the production of fish through farming. This framework is not cast in stone and has been evolving for the past one thousand years or so.

In conclusion, it should not be surprising when, as either fishermen, farmers or private citizens, we encounter different opinions and certainly some confusion regarding the use of clam resources. What needs to be done is to rationalize the allocation of resources to meet the needs of various people.

Please treat this workshop as a forum to address your concerns and expectations and to suggest ways to benefit all concerned.

INDUSTRY PERSPECTIVE ON CLAM FARMING IN BRITISH COLUMBIA

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In order to give an overall perspective into the state of clam aquaculture in British Columbia I believe we should take a quick look back to the past.

Ten years ago, I suspect most growers in B.C. were not concerned with clam culture though preliminary work with Manila clams had already begun. Dr. Neil Bourne and Mr. Dwight Heritage of the Department of Fisheries and Oceans (D.F.O.) for example had set up a small seeded plot on Denman Island to monitor seed survival and growth. In addition Canadian Benthic Ltd., through funding by the Science Council of B.C., had begun work on the nursery raising of clam seed.

While many were keen to continue the work, the lack of a federal/provincial agreement to allow the possibilities of clam culture halted research on Manila clam farming. It would be almost eight years until the jurisdictional framework was developed to allow the industry to proceed.

Two years ago the Ministry of Agriculture and Fisheries (M.A.F.) sponsored the first Manila clam culture workshop, which was held in Parksville. This workshop afforded an opportunity for industry to start a dialogue with governments, which in turn has led to further changes in government policy and regulations.

In 1990 a workshop on research needs for the development of the clam farming industry was sponsored by the B.C. Aquaculture Research and Development Council. This workshop helped priorize the research needs.

The Science Council of B.C. financed three Manila clam research projects this year. These projects include:

* Innovative Aquaculture Products Ltd./ Redonda Sea Farms Ltd.
  - study of nursery systems for juvenile clam seed.

* Canadian Benthic Ltd./University of Victoria
  - study on feeding mechanisms in juvenile clam seed.

* IEC Collaborative Marine Research and Development Ltd.
  - an economic evaluation of Manila clam farming in B.C.

In addition, M.A.F. has sponsored a six site grow out study to introduce the concepts of clam farming to industry members through technology transfer.

At the present time a number of leases have been converted to clam culture and companies like Fanny Bay Oyster Company, Redonda Sea Farms

Ltd., B. and J. Shellfish, Madrona Shellfish Company and individuals like Mr. R. Langley, Mr. S. Logan and Mr. R. Dunsmore have seeded beaches in early attempts at Manila clam culture.

In the short term I would expect the wild fishery to stabilize, if not decline slightly, in the next few years. This of course is dependent on whether D.F.O. opens additional harvesting areas on the north coast. This situation bodes well for clam farming and production will no doubt increase initially through the harvesting of wild clams on shellfish tenures prior to the planting of seed clams.

With the addition of an increased, and hopefully a more stable supply of product from our early clam farmers, the markets will stabilize and farmed product will initially fill the gaps from holes in the wild fishery resulting from conservation closures.

Clam farming does not take place in a vacuum and major issues will affect the growth and future of this industry. I have identified the following issues as important:

Quality Control - Clam farming allows the farmer to harvest product on a predetermined schedule. For example, product can stay in the beach until an order exists for their purchase. This will, hopefully, avoid the current wild fishery practices of "harvest now - sell later". With the advent of purging and temperature control through to the customer, farmed clams can be a prime quality seafood. Failure by the industry to recognize this fact will result in a lack of recognition by consumers that farmed clams are superior in quality to wild clams and any hoped for price differential will not be forthcoming;

Water Quality and Product Safety - As we continue to dump domestic and industrial wastes into our waterways, the quality of our water and eventually our seafood deteriorates. In most areas of coastal North America, shellfish have already been impacted by poor water quality. Chesapeake Bay, Florida, the Gulf States and portions of the West Coast have product which has caused illness in consumers, usually from the consumption of raw shellfish.

In British Columbia we are not immune to this result as our waste disposal practices are not much different from other areas. In B.C. we have approximately 15,000 hectares under shellfish closures due to domestic and industrial pollution.

Product safety is also impacted by the occurrence of natural toxic phytoplankton blooms. Our federal inspection program has effectively protected the consumer from such products being put on the shelves. However, a lack of resources by these agencies has often resulted in a negative impact on the grower;

Government Policy and Regulation - In the past few years we have managed to overcome much of the restrictive government policy which has impeded the development of the clam farming industry. The provincial/federal Memorandum of Understanding (M.O.U.) on aquaculture and the Letter of Understanding (L.O.U.) on clam culture are current examples of progress in this matter. Recent developments within the provincial Ministry of Crown Lands (M.C.L.), however, in which a moratorium was placed on the conversion of oyster to clam tenure suggests that industry members and associations will have work cooperatively to encourage government policy and regulation to develop in a way which will support the development of clam culture in B.C.;

Diligent Use of Existing Tenures - The current policy of the M.C.L. is that no untenured crown lands are available for application for purposes of clam farming. This requires, therefore, the better use of existing tenures. Some companies in B.C. are in the position where they are no longer able to expand their production due to a shortage of available land in their area. At the same time, certain oyster lease holders do not diligently utilize the tenures that they have. The policy of diligent use has been endorsed by industry and government and a major issue over the next few years will be the reallocation of nondiligent tenures to new or expanding growers;

Research and Development - In order for an industry to progress, research and development coordination and funding are required. In this area it is crucial to define the role of the federal government in aquaculture as outlined in the M.O.U.. Currently the B.C. Aquaculture Research and Development Council, under support from provincial funding agencies, maintains an active presence in the area of research and development of aquaculture in B.C.; and,

Public Perception - Few things can adversely affect the future of this industry more than negative public perception. This was made very evident this summer when the efforts of a few local inhabitants of Gilles Bay on Texada Island resulted in a moratorium being placed on the further conversion of oyster to clam tenures. The clam farming industry has nothing to be ashamed of and it is important to educate the public on the benefits this industry will have on local and the provincial communities.

In conclusion, I believe that the participants of the clam farming industry have the opportunity to coordinate their activities at the birth of their industry. I suspect it will take the coordinated efforts on behalf of industry and governments to deal with these issues to allow the clam farming industry in British Columbia to develop and survive on its own merits.

PERSPECTIVE OF THE MINISTRY OF CROWN LANDS

Dr. Tom Cockburn

Ministry of Crown Lands
851 Yates Street
Victoria, British Columbia
V8V 1X5

As most of you are aware there have been some concerns raised by the Minister of Crown Lands on the issues surrounding the development of the clam farming industry. Discussions were held on this matter in August and September between our Minister and the Minister of Agriculture and Fisheries. In their September meeting, which was also attended by industry members, a policy on dealing with applications for clam tenures was developed.

This addition (attached) to our Ministry aquaculture policy was needed because clam farming is different from other aquaculture efforts. Our current policy is that clam farming may be authorized only on Crown land which currently is alienated by an existing shellfish tenure. This may seem quite restrictive, however, from our perspective, we already have 1,500 hectares under shellfish tenure which presents a lot of opportunity for clam farming. The Minister's direction is that only existing shellfish tenures may be used and that there will be no new Crown land for clam farming at this time. Our Ministry wants to make sure that the best use of the land that is currently under tenure is made. We recommend a cautious start of this industry as we do not want to see the same mistakes, example gold rush, that were made at the start of the fish farming industry.

There are concerns with clam culture, in the public view, and we feel if you proceed with these concerns in mind you will have fewer problems. The public is very protective of foreshore recreational use and beach access. For example, the issues of beach improvement and predator netting will no doubt cause concern among those public who do not understand what clam farming is about.

Our advice is to be sensitive to public issues and to be prepared to educate the public on these issues. If you require modifications, nets, etc., we suggest you contact the upland owners and nearby residents and discuss it with them to let them know what you want to do. We expect this will prevent many problems.

Our regional offices will process clam farming applications using standard procedures. Since clam farming will take place on existing tenures, most of your application process has been completed. You will be required to submit a new Shellfish Development Plan to the regional office to add clams too or to convert your tenure to clam culture. The boundaries of the shellfish tenure cannot be altered to accommodate clams, therefore, existing boundaries will remain the same. The definition of an existing shellfish tenure is a tenure that was approved on or before September 30, 1990.

Upon receipt of your documents, a referral on your clam farming application will be sent to Ministry of Agriculture and Fisheries, Department of Fisheries and Oceans and local governments. In most cases, since you already have a tenure, there will be no need to re-advertise. However, if public concerns are anticipated or arise, our regional offices may implement additional procedures as appropriate, to deal with special circumstances. These special circumstances may require re-advertising or for you to hold an information meeting with concerned property owners.

The Ministry of Crown Lands is looking to make this process progressive and not contentious, we are encouraging the success of clam farming. As with other uses of Crown land, we view clam farming as a viable and productive industry. We advocate a cautious approach and that the clam industry prove itself through its track record.

DIRECTIVE 90-09-28

L.A.M. SECTION 3.2.0400

SHELLFISH AQUACULTURE POLICY

1.0 PURPOSE

To clarify the aquaculture policy regarding applications for clam aquaculture further to Directive 90-08-31.

2.0 BACKGROUND

(a) Directive 90-08-31 stated that because of concerns regarding public access, recreation, aesthetics and competing land/resource uses, all applications for clam aquaculture were to be held in abeyance until the situation had been clarified.

(b) The Ministers of Crown Lands and Agriculture and Fisheries have determined that clam aquaculture applications (both new and those in abeyance) may proceed under the policy described below.

3.0 POLICY

Effective October 1, 1990 clam aquaculture applications may be accepted and processed following Ministry policy and procedures (eg. development plans) subject to:

(a) Clam aquaculture may be authorized only on existing shellfish tenures approved on or before September 30, 1990. Clams may be added as an additional species grown on the tenure, or the entire tenure may be converted to clam aquaculture as long as no new area is added to the existing tenure;

(b) Sites of existing shellfish tenures approved on or before September 30, 1990 which may later be cancelled or abandoned may be re-allocated for clam aquaculture;

(c) Applications for clam aquaculture will not be accepted or tenures approved for new Crown land areas until further notice.

(d) The Regional Director, in consultation with the Ministry of Agriculture and Fisheries, is to help the public understand what is being proposed with clam aquaculture and where it is being proposed. If public concerns are anticipated or arise, the Regional Director may implement additional procedures, as appropriate, such as:

- requiring the applicant to re-advertise so that the public is informed of the proposal;
- the region undertaking referrals to appropriate agencies and local governments;
- requiring the applicant to hold a public information meeting to address public concerns;
- other measures deemed necessary by the Regional Director.

90.09.28
DATE

FRANK G. EDGELL
ASSISTANT DEPUTY MINISTER

PERSPECTIVE OF THE MINISTRY OF AGRICULTURE AND FISHERIES

Mr. Ken Albrecht
Ministry of Agriculture and Fisheries
Aquaculture and Commercial Fisheries
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I would like to go back about ten years to when I first started with the government and give my perceptions on how we have reached our present point in the development of Manila clam culture in British Columbia. I would then like to discuss where this industry is heading and the role that the Ministry of Agriculture and Fisheries (M.A.F.) will play in it's development.

Ten years ago the clam diggers and oyster growers coexisted harmoniously, mainly because there were fewer diggers and more clams to go around. Also the focus at that time was on the Butter clam, rather than the Manila clam, therefore, digging was, for the most part, taking place at lower tide levels, below the oyster leases. Most of the clam diggers respected the investment that oyster farmers had on their leases and stayed off the tenure. In 1982 there was a market shift from Butter clams to Manila clams which, I believe, resulted in the subsequent breakdown of the congenial relationship between the two groups.

About six years ago we experienced a recession across Canada. As a result, unemployment increased and a larger number of people tried to make a living off of the wild clam resources. An increase in the price of Manila clams in the market place completed the picture and the result was the beginning of the decline in the Manila clam fishery. Naturally the diggers began to realize that clam populations were higher on oyster leases as oyster farmers often did not dig the clams for fear of disturbing their oyster seed. This resulted in increasing hostilities between oyster farmers and clam diggers.

To intervene in this situation, M.A.F. and the Department of Fisheries and Oceans (D.F.O.) signed a Letter of Understanding (L.O.U.) which gave lease holders the ability to control clam digging on their leases. Clam digging upon leases, however, could only occur during the appropriate harvest season and leases had to be marked with standard red concrete blocks. A clam harvesting schedule had to be submitted and approved by M.A.F..

All infractions by diggers were to be handled by federal Fisheries Officers under Section 21 of the Fisheries Act. It states that no person shall fish for, catch or take fish within a lease/licence area unless they were authorized by the lease holder. Nor can they disturb or interfere with any such fishery.

Two problems still existed within the fishery. Due to the depletion of the wild clam stocks, D.F.O. had tightened up their restriction on digging and reduced the length of digging time in order to conserve the wild clams. As the lease holder was bound by the imposed clam harvest schedules, they could not efficiently manage their tenure by digging clams when it was most convenient for them. In addition, over harvesting resulted in a shortage of clams for the markets and the price of clams subsequently increased.

In order for the clam industry to prosper and grow it must be able to provide a consistent supply of high quality product to the market place, twelve months of the year. Industry cannot continue to rely on the wild fishery and the solution may be clam culture. This would allow harvesting for twelve months of the year and the opportunity for intensive management to ensure sustainable yield at levels of maximum production. Now that the clams are "privately owned", lease holders can no longer rely on D.F.O. to enforce illegal harvesting on a lease. Theft of private property is a civil matter and should be dealt with through the Royal Canadian Mounted Police (R.C.M.P.) or local police.

Up to about two years ago, clam culture in B.C. was not allowed under the provincial leasing system due to the jurisdictional dispute between federal and provincial agencies. Under this scenario the clams were a resource which belonged to the public at large. But due to the decline of the wild stocks and pressure by industry members , D.F.O. agreed, in principle, to allow clam culture on existing oyster leases and also on beaches that did not have commercial or recreational populations of clams.

The L.O.U., which defines the role of each agency, has been drafted but at this point remains unsigned.

Recently the Ministry of Crown Lands (M.C.L.) has written a policy which allows clam farming only on existing oyster leases. While it appears that M.C.L. is only being cautious, their policy seems redundant as the L.O.U. between M.A.F. and D.F.O. appears to already address this matter. The M.C.L. policy at this time seems like a step backwards.

The current situation allows persons to apply for an oyster lease on untenured crown land but not a clam lease. And once you have an oyster lease you cannot convert it to a clam lease if your lease was not in place prior to September 30, 1990.

I believe to address these concerns the industry should make every effort to utilize their existing leases wisely and diligently and prove that the industry is responsible, productive, well organized and viable. They must prove also that clam farming is good for the province's economy and that it can coexist with other user groups, particularly the public and upland owners. They must show that the industry is environmentally friendly and that obtaining an oyster lease is not just a ploy to obtain exclusive rights to the wild clam stocks. This is why we insist that a minimum level of seed be planted in order to meet the criteria for clam culture.

The role of M.A.F. in this matter is to work cooperatively with D.F.O., M.C.L., the public and industry. Also to deal with the new policies of M.C.L. and then work to identify other areas of vacant crown land that may be able to be used for clam culture in the future. These beaches may have no commercial value and may be above, or surround, existing oyster beaches or be in areas of low recreational use. In this way we may be able to free up additional land for a developing clam farming industry.

M.A.F. will continue to play a key role in identifying resources for research needs and extension services to the industry, such as this workshop, and to disperse information or new technologies. M.A.F. will also continue to play a role in conserving water quality and ensuring the diligent use of existing tenures. As the resource base becomes more limited, the Diligent Use Policy will become more important in the future.

In conclusion we will continue to work with industry, to ensure sustainable growth and development of the clam farming industry in British Columbia.

FEDERAL GOVERNMENT POSITION

Ms. Frances Dickson

Department of Fisheries and Oceans
555 West Hastings Street
Vancouver, British Columbia
V6B 5G3

The Department of Fisheries and Oceans (D.F.O.) is supportive of a viable clam culture industry in British Columbia and as you know will be signatory to the Letter of Understanding on clam culture now that a departmental review has been completed. The Department recognizes that the wild fishery alone, as presently managed, is unable to supply a consistent year round supply of clams to the market. This agreement provides a mechanism to prove out clam culture on existing approved shellfish tenures, with suitable intertidal foreshore, subject to an approved development plan being filed. It also provides a formal mechanism for planning for future expansion of the industry subject to evaluation of the current fishery. Therefore, it is important that clam culture tenures are properly farmed to their potential and that due diligence is achieved.

The federal government is working with the provincial government to define acceptable production methods and harvesting yields for clam culture operations. For the immediate future a minimum seeding density of 200 clam seed per square meter per year is required.

Clam seeding can be complemented by other enhancement techniques to improve clam production. Due to the fact that clam culture leases will benefit from seeding from adjacent wild beaches, there will always be a mix of wild and cultured clams on a clam culture operation. This makes it different from other culture operations where you have virtually a 100% population of cultured shellfish or fish. As these cultured beaches will be getting wild seed on them, it has been agreed that all clams harvested from clam beaches must be the legal minimum size (shell length >= 38 mm). This is to allow for cultured clams to spawn once before they are harvested. In that way they will also be seeding adjacent beaches just as they receive wild seed from other beaches.

The Ministry of Agriculture and Fisheries is the lead agency for all culture activities in B.C. However, D.F.O. will continue to inspect all clams in federally registered shellfish plants: checking for quality, minimum size and tagging compliance. It is a regulation in B.C. that all shellfish harvested from a fishery, or a culture operation, must first go through a federally registered plant. D.F.O. will also continue to operate mussel stations which have been established for the detection of paralytic shellfish poisoning (P.S.P.) and closures for all bivalve fisheries, including clams, will be implemented should a P.S.P. outbreak be detected.

Departmental scientists and managers will be working with the province in the assessment of the success of clam culture both technically and economically. Together with industry, the technical requirements for clam culture will be revised as more information is obtained.

D.F.O. will not be responsible for enforcement on clam leases as already mentioned, however, we will continue our enforcement program with respect to wild clam fisheries on oyster tenures. We will be working with the provincial agencies of Crown Lands and Agriculture and Fisheries in Baynes Sound, which has been established as a test area, to rationalize some of the oyster tenure boundaries in that area.

Our Department believes that it is most important to carefully document the success of clam culture over the next few years. Government and industry must be able to prove to the public that clam culture is working, that it does provide increased production over what can be obtained from the current wild fishery and that a better product can be marketed with increased economic benefits to the province.

Careful planning for future expansion must start now and it must include all user groups. While there is somewhat of a freeze on clam culture, we should start planning, right now, for future expansion. We are all assuming that clam culture is going to work.

The planing process must include the upland owner, recreational and commercial harvesters, the native Indian community and the general public as well as all affected government agencies. This planning must be complimentary to the technical and economic assessment of clam farming itself. D.F.O. is prepared to actively participate on both these fronts.

One of the primary limiting factors affecting the future expansion of Manila clam culture is the conflict between other users of the intertidal foreshore, including the upland owners and fisherman of all types. Their needs must be recognized as you plan for expansion. At this time a number of recreational reserves have been set aside for recreational harvest. When clam culture is expanded, these will have to be reviewed and possibly increased.

Our Department will work with native Indian bands to encourage clam culture opportunities on beaches fronting their reserves. In addition, their needs for food fish harvest must always be allowed for whenever clam culture is expanded.

One problem which could possibly inhibit the expansion of the clam culture industry is the trend to use the C.R.I.S. (Coastal Resource Inventory Study) maps which were developed primarily for finfish and shellfish aquaculture opportunities. These maps should be modified, or a new set of maps should be produced as part of the planning process which would identify aquaculture zones of opportunity. Unless this is done, restrictive coastal zoning may limit clam culture opportunities in the future.

In summary, D.F.O. is fully supportive of the short term approach of approving clam culture on approved shellfish tenures. D.F.O. will provide technical information and encouragement to native Indian bands wishing to develop clam culture operations on beaches fronting reserves. There must be widespread public consultation prior to re-leasing any additional intertidal foreshore for clam culture. The success of this consultation will be dependant on the documentation and the success of clam culture on leases being operated in the next few years. It is extremely important that due diligence be adhered to and enforced by the appropriate provincial agencies. Enforcing due diligence on clam leases will be much more difficult for clams and will undoubtedly require more resources. Clam culture offers an opportunity to enhance clam production and to bring stability and improved benefits to the industry. D.F.O. hopes that it does succeed.

STATUS OF THE CLAM FISHERY IN BRITISH COLUMBIA

Mr. Rick Harbo

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In 1989, intertidal clam species ranked second in landed weight of shellfish and third in landed value.

Four species are taken in the intertidal clam fishery: Manila; native littleneck; Butter; and, Razor clams.

Landings and Value

Figure 1 shows the annual landings of the four species of clams and mixed (Manila and littleneck) clams from 1979 to 1989. The landings and landed value of clams peaked in 1988.

In 1989, the combined landings of steamer clams was 3,316 tons: 2,728 tons of Manila clams; 428.4 tons of littleneck clams; and, 159.3 tons of mixed clams. There was a decrease of approximately 29% by weight of Manila clams (Figure 1). There has also been a decline in mixed clam landings reported, but this reflects a change in buying practices. Clams reported as "Manilas" often contain a mix of native littleneck clams. This means that the decrease in Manila clams was actually greater than 29%.

The landed value of Manila clams in 1989 decreased by only 14.3% (Figure 2) due to an increase in the average price of $0.98 per pound. There were 31 companies that processed clams in 1989.

Intertidal Clam Management

Size Limits

The primary conservation practice in the intertidal clam fishery is rigorous enforcement of minimum size limits. The minimum size limits are set to allow the clams to spawn at least once before they are taken in the commercial fishery.

The minimum harvest size for Manila clams is 38 mm through the longest diameter of the shell. Cultured clams will also have to be grown out to this minimum size before harvested.

A second conservation concern is to prevent mortalities of sublegal size clams from repeated digging of beaches.

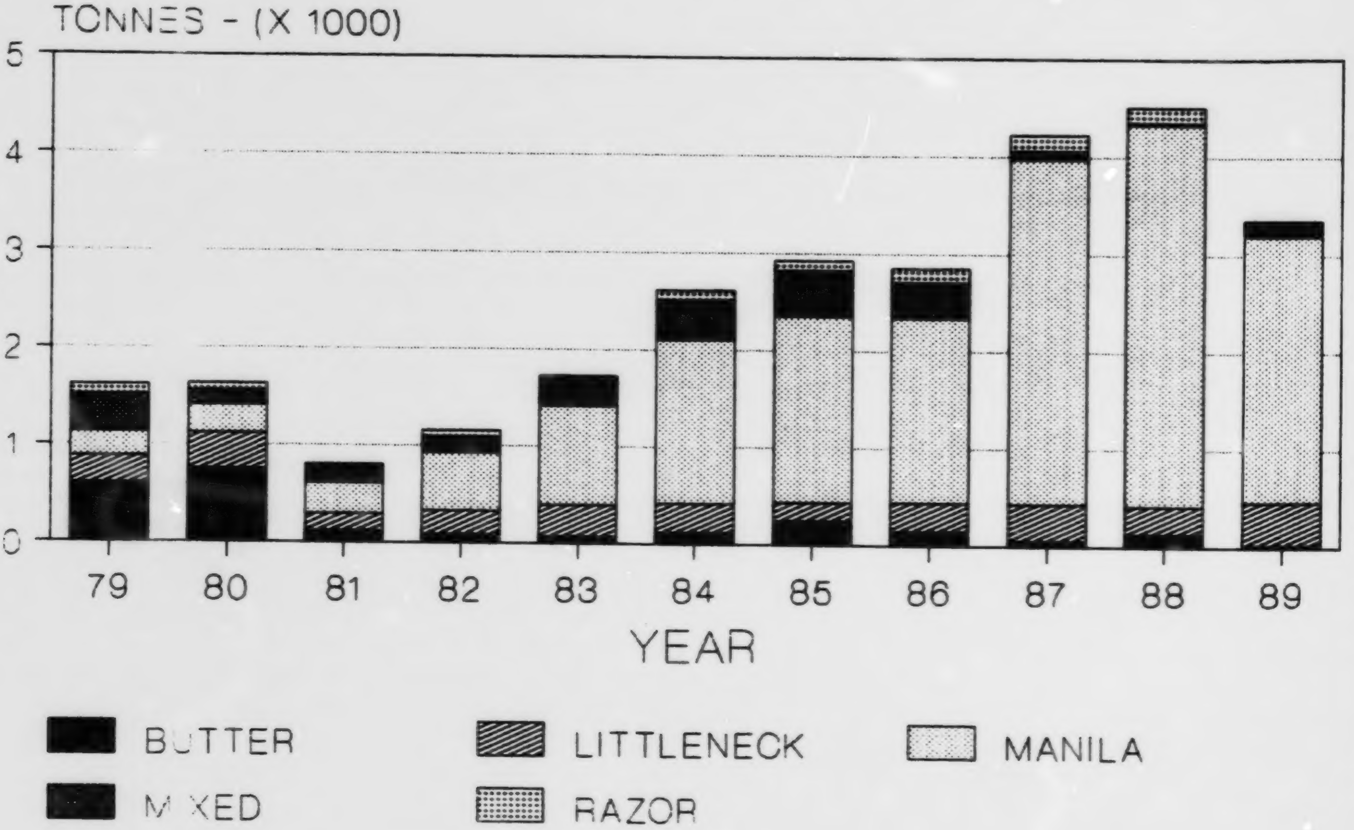

Figure 1. Annual clam landings 1979-1989 total for B.C.

Area Licensing

In 1989 and 1990 the coast was divided into six clam management areas and harvesters had to choose one area for the year. The six areas are:

A. North Coast : Pacific Management Areas (P.F.M.) 1-10 are currently closed due to high risk of paralytic shellfish poisoning; subarea 1-5 is open for the harvest of Razor clams only
B. Johnstone Strait : P.F.M. Areas 11, 12 and 13
C. Sunshine Coast : portions of P.F.M. Areas 15 and 16
D. Upper Strait of Georgia : portions of P.F.M. Areas 14 and 16
E. Lower Strait of Georgia : P.F.M. Areas 17,18,19 and 20
F. West Coast of Vancouver Island : P.F.M. Areas 23-27

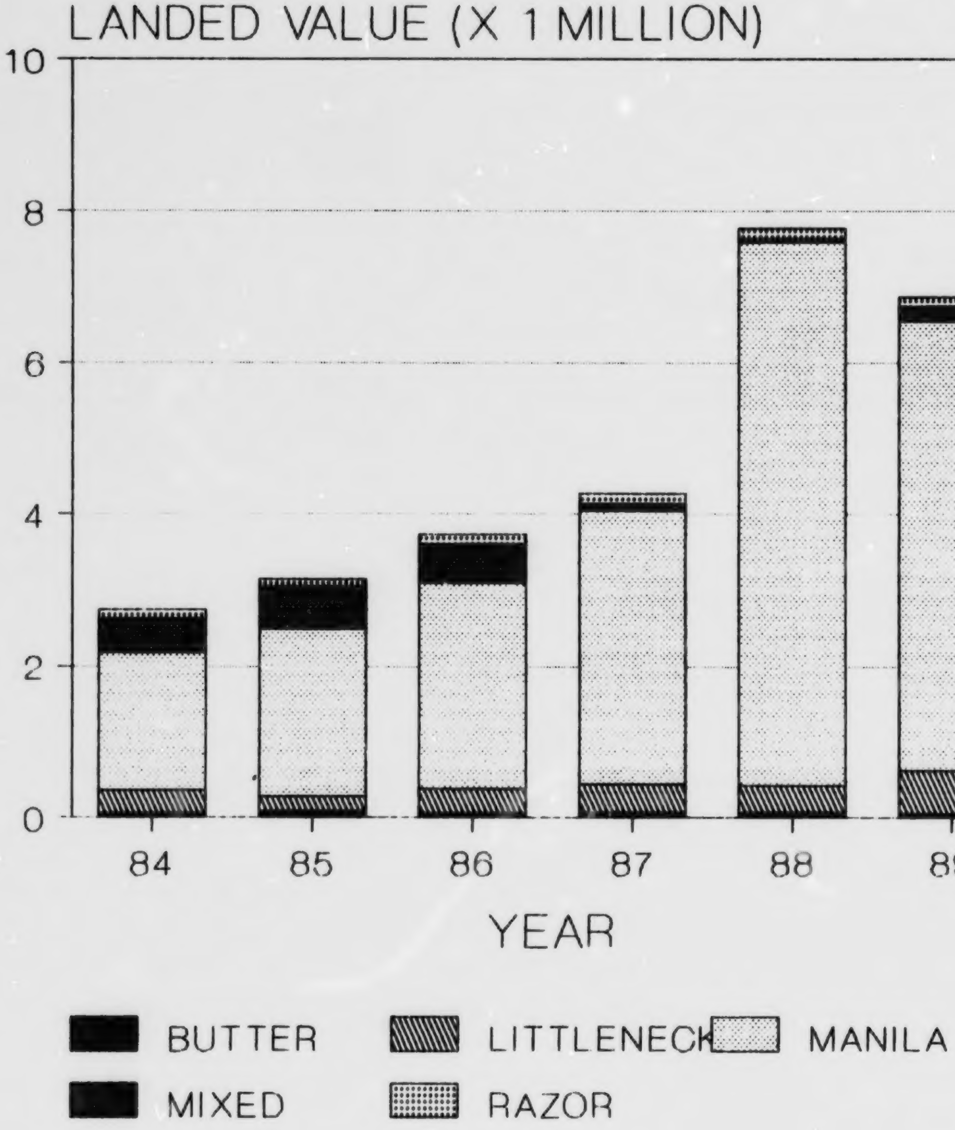

Figure 2. Landed values of intertidal clams 1984-1989.

Clam Harvesters

A license specific to intertidal clam harvesting was introduced in May, 1989. In addition to the personal Z-license for clams, a Personal Commercial Fishing License is also required. In 1989, a total of 1,870 licenses were issued and the number per area is as follows:

Area	Description	# of Licenses Issued
A	North Coast	10
B	Johnstone Strait	224
C	Sunshine Coast	400
D	Upper Strait of Georgia	421
E	Lower Strait of Georgia	374
F	West Coast of Vancouver Island	441
	SUM	1,870

Seasonal Restrictions

The seasons were reduced in 1989 and 1990, both in an effort to provide a year round supply of clams and to address conservation concerns arising from the repeated digging of beaches. Mortalities of sublegal size clams occur from breakage and exposure as a result of harvesting activities. The mean size of clams harvested appears to decrease over the period of an opening and increasing numbers of sublegal clams appear in the catches.

In some areas, openings were restricted from 2-4 days per week.

Clam Beach Inventory

There are approximately 27,000 km of shoreline in British Columbia with beaches varying from a few square meters to several hectares (Ha).

We have updated our inventory of clam beaches in the south coast this season. We have identified 664 commercial beaches, 216 used for Indian food fisheries and 636 recreational beaches. The total area protected is 8,110 Ha (approximately 20,000 acres). This compares to approximately 250 leases and 2,000 Ha (5,000 acres) under tenure for oyster culture.

A preliminary survey of Manila clams was carried out in the north coast and commercially harvestable quantities were found in P.F.M. Area 7. Sanitary growing water surveys, a paralytic shellfish monitoring program and resources for management and enforcement are required before a commercial fishery can take place.

The current policy, in effect since the mid 80's, is that new leases will not be approved in areas that may support a native food, commercial or recreational clam fishery. In practice this means that if any clams are found on the proposed lease, it will not likely be approved.

Native Food Fishing Reserves

A number of beaches will be identified as reserves for Indian food fish purposes. Commercial harvest will not be permitted on these beaches. There will be consultation with native bands to encourage clam culture in suitable areas, particularly those fronting Indian Reserves.

Recreational Reserves

There are currently 15 recreational reserves, all situated in the Strait of Georgia. These areas are detailed as closures in the commercial clam licence.

Conservational Closures

The Department of Fisheries and Oceans has closed some areas in 1989 and 1990 due to their low abundance of legal and sublegal clams. Due to conservation concerns, Savary Island (subarea 15-2), Mary Basin (subarea 25-14) and all of Area 26 were closed in 1990. Short term beach closures of 1 or 2 years in Clayoquot Sound (Area 24) and an area closure of Barkley Sound (Area 23 : in 1980/81/82 and 86) did not appear to result in an overall increased recruitment. Recruitment was different at each site sampled. Such closures do, however, prevent mortalities from repeated digging.

The following criteria are evaluated in the decision for a conservation closure:

1. Management is by Area, not by beach or beaches.
2. Conservation: protection of spawning stock - "minimum size limits", closures are considered when there is a high incidence of sublegal clams.
3. Digging in contaminated areas.
4. Repeated digging on beaches. This is considered to increase mortalities. Digging once per week is an improvement over seven days per week.
5. Declines in digger catch per tide; declines in the number of diggers.
6. A shift in species composition from Manilas to littlenecks or mixed clams.
7. Digging in the "marginal habitats" suggests that the major beaches have been heavily harvested.
8. Encroachment on oyster leases, in areas such as Baynes Sound.
9. An increase in the amount of sand, mud and rocks in the sacks.

PANEL DISCUSSION

Mr. Bill Roland Ministry of Agriculture & Fisheries
Moderator

Question : Does it seem to the panel that there is an imbalance in the investment differential between a commercial clam harvester and a clam farmer? Fisherman have a very low investment and they have a very large area of a coast in which to pursue their livelihood. While clam farmers are faced with all sorts of costs associated with maintaining equipment, lease fees and taxes, paying employees and other associated costs. Should we not be able to harvest at any size we wish as the clams are our own private property?

Ms. Frances Dickson : Department of Fisheries and Oceans (D.F.O.)

The minimum seeding requirement was jointly agreed to by both federal and provincial governments. The difference between the rights of wild fisherman and a farmer are quite substantial. Someone who has a tenure for clams has the total rights to all clams on that beach, including the wild clams, and the right to harvest at any time of the year subject to health and safety closures. It is also my understanding from discussions with growers from Washington State that they do not believe it is economical to harvest clams at just the legal size limit and tend to market clams at larger sizes. A clam fisherman, however, can fish only where and when D.F.O. says he can.

Question : I suggest that the fee for a commercial clam harvester be increased from $10 to perhaps ten fold, or more, to fund fisheries enforcement efforts to ensure that commercial diggers do not encroach on leases.

Ms. Frances Dickson : Department of Fisheries and Oceans (D.F.O.)

The licence fees are currently under review. Meetings will be held with industry and the public. However, you should realize that we felt that by giving farmers the exclusive rights to clams, which have always been considered a common property resource, we also required a commitment from the farmer to ensure proper use of this resource. That is why we agreed to the minimum seeding requirement. The seeding requirement may be temporary and will be reviewed in the future as more information becomes available.

Question : We continually have to keep diggers off of our clam farms. Why do we have to do the job of the Fisheries Officers?

Ms. Frances Dickson : Department of Fisheries and Oceans (D.F.O.)

As a result of conservation closures, some areas are open for digging only one or two days per week over a limited time period. Fishery officers cannot always be available at all times while closures are in effect, due to availability of staff resources we cannot be everywhere at once. Perhaps it is possible to find a way to mark farmed clams to make them easier to identify by enforcement personnel.

Question : I am a commercial digger and I have approximately $40,000 dollars tied up in capital equipment. With the restriction of clam farms to existing oyster tenures how does someone like me, or other commercial diggers, manage to get a clam farm going from scratch? In effect I am being told that as participant in this industry for a number of years, I am now being shut out of the industry. What options are there for people who have a proven record in the clam industry to apply for a clam farm? Also, there are a number of oyster leases on the west coast that do not comply with the red block requirements. What is being done about this?

Ministry of Crown Lands (M.C.L.) Representative

You perceive a lack of opportunity to get into the clam farming industry? While at this time the Minister has made it clear that clam farms will not be given out on untenured foreshore, this may change in the future. An opportunity may exist in the future.

Mr. Jim Anderson : Ministry of Agriculture & Commercial Fisheries (M.A.F.)

I would suggest to clam diggers that D.F.O. will soon be holding public review meetings to discuss licensing policies. Any digger that wants to suggest changes to the system might want to go to these meeting and represent their side of the industry. Diggers may want to suggest that changes to the federal license, i.e. through Individual Transferable Quotas (I.T.Q.), may bring them closer to the rights of a clam farmer.

Question : Is the Ministry of Crown Lands to be a signatory on the Letter Of Understanding (L.O.U.) between M.A.F. and D.F.O.?

Ministry of Crown Lands (M.C.L.) Representative

No. We have been consulted on the agreement but the L.O.U. deals primarily with the technical situation of culture versus wild stock.

Question : The reason I ask is that the M.C.L. just put up a road block to the development of the clam culture industry in B.C.. A number of reasons for putting on a moratorium were all matters that are contained in the L.O.U. and if the M.C.L. is philosophically in agreement with those policies we should not have had this problem. I can see we will continue to have these problems in the future if the M.C.L. is not involved with the policies being developed by M.A.F. and

D.F.O. Is there any ongoing discussion between M.C.L., M.A.F. and D.F.O. that will allow some sort of compromise on these issues?

Ministry of Crown Lands (M.C.L.) Representative

M.C.L. is the only agency that authorizes the use of Crown land and the L.O.U. does not specifically deal with that matter.

Question : Our farm is in the position where we have had netting on the beach since the summer of 1988. Therefore, we have caught three summers of clam spatfall on our beach. We are now getting overcrowding under our nets. We are at a point now where if we seed next year we will be throwing our money away and jeopardizing the seed we have already put down. Can the minimum seeding planting be relaxed in cases such as this? Is it permissible to move some of the undersized clams to other areas of the lease or to another lease?

Ms. Frances Dickson : Department of Fisheries and Oceans (D.F.O.)

D.F.O. may allow you to move the clams around on your beach subject to certain conditions. D.F.O. would have to deal with your case specifically but we would definitely not allow you to sell undersized clams. D.F.O. will only address an issue like moving seed in joint consultation with other government agencies based on a proposal from you.

Question : The Nanoose Band is a Douglas Treaty Band. Do any of you have any information that relates to the band? We have court cases that state that we have the rights to the food resources within our treaty areas. Are people within the industry aware of the implications? Because if so, they could run into some problems with locating their leases. And, directed to M.C.L., it would not be in our interest to apply for a clam tenure fronting our reserve as by making application we would be, in essence, agreeing to your Ministry's control over land which the Douglas Treaty says we have the rights over anyway. By following your procedures we would be acknowledging your control which we chose not to do given recent court decisions on native land claims.

Ministry of Crown Lands (M.C.L.) Representative

I cannot give an official response regarding native Indian land claims. Let me just repeat that if you are interested in pursuing aquaculture activities we encourage you to contact us and we will discuss the matter further.

Question : What is the present protocol between M.A.F. and M.C.L. to formalize ongoing decision making on land tenure use?

Ministry of Crown Lands (M.C.L.) Representative

The two Ministries are in the process of developing a formalized agreement. Because of the introduction of the Agriculture Licensing program by M.A.F. there are now two licensing programs in effect on each site. The agreement will firm up a consulting process which ensures cooperation and that neither party takes independent action on its own. This agreement is almost ready to be signed.

Mr. Jim Anderson : Ministry of Agriculture & Commercial Fisheries (M.A.F.)

No one would sign a provincial/federal agreement such as the M.O.U. and L.O.U. without the consultation between all effected provincial Ministries. All Ministers of M.A.F., M.C.L. and D.F.O. were on side until the problem with the upland owners on Texada Island took place. At that time the Minister of Crown Lands asked the Minister of Agriculture and Fisheries to reconsider the agreement that was about to be signed by D.F.O. After discussions between the Ministers it became evident that the problem could be addressed within the provincial mandates and he gave his concurrence for the agreement between M.A.F. and D.F.O. to be signed. In addition, as Mr. Tom Cockburn mentioned, there is a major agreement being developed between M.A.F. and M.C.L. on how tenures will be administered and issued with licences. Particularly with the purposes of minimizing paper work and increasing the cooperation between Ministries.

Question : Is there an opportunity for industry to preview the document prior to its signing?

Mr. Jim Anderson : Ministry of Agriculture & Commercial Fisheries (M.A.F.)

I would think so.

HATCHERY AND NURSERY CULTURE OF THE MANILA CLAM

Mr. Paul Taylor

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98584

Our hatchery facility is located on Dabob Bay, near Quilcene, Washington. The facility includes our eyed larvae setting ponds, three algae ponds, a main hatchery building and an algal start up building.

We buy algal innoculants from Bigalow Laboratories, an algal producer in Maine. The innoculant begins in a test tube and eventually goes into bag culture or tube tanks prior to feeding our larvae. We also can send the algae to larger ponds to be grown in larger volumes to feed our nursery or broodstock. The bag and tube tanks are used to feed our larvae. We produce Muelleri gracillis and Tahitian Isocrysis as our major food sources.

Our broodstock clams are selected by size and fast growth characteristics. We do not, as yet, have a formal broodstock program in effect. Most people suggest that as our broodstock comes from Puget Sound, they might grow better in the Sound than they might in Canada. I think if you are growing clams in British Columbia, your broodstock should come from British Columbia.

Our clams are placed in a 55 gallon (250 litre) drum and are enticed into spawning by elevating the water temperature and feeding them large concentrations of algae. Once they have spawned, the larvae is collected and put into 12,000 gallon (54,600 litre) tanks. They are fed daily for about two weeks. We have had some problems raising clam larvae through the 140 micron size as there is inconsistent survival between batches. Many of our problems have been solved in our first year, however, we have not reached perfection yet.

After the clams settle out of the water column, we use a downwell system. Normally we take the seed off of the set screens when they will hold on a 315 micron screen. Seed does not do well in our "updrafts" after about 1 mm in size.

Water is supplied by a pump to a header box which provides a continual flow to our updrafts. Another method that can be used is to take clam larvae that has just settled out and put them in a raft filled with about one inch (2.5 cm) of sand. The ends are covered with Nitex screening to prevent the escape of the larvae. About 5,000,000 larvae are added per float. The floats are about 36 feet long (11 meters) and 8 feet wide (2.5 meters) on the inside. They are made of plywood and 2" x 12" boards. The cost is about $500 (U.S.) each. We take the rafts out of the bay every winter to prevent storm damage and problems with wood borers.

After the clams have been in the raft about two weeks, I remove the Nitex screen so that water flow is increased. We have not yet determined if sand, crushed shell or a mixture of the two is better for a substrate. When clams are very dense they do not use the substrate but layer up to an inch thick (2.5 cm) on top of it.

Our best survival is achieved by putting clams in the raft in April or May. If we put them in later in the year, survival can be nil. We have had our best success in growing clam seed in the hatchery, to about 600 micron size, and then putting them into the floats.

The raft is built by taking two 18 foot (5.5 meters) 2" x 12 " boards patched together with a 10 foot (3 meters) 2" x 12" board. A piece of plywood, cut in half, is used for the sides. Styrofoam fill the sides so that it floats about 12-18 inches (0.3 meters) deep. The rafts are covered to prevent the growth of macro algae, which blocks water flow. Thin plywood seems to work the best for this. Wire is used with supports to prevent the plywood from sagging.

Another system, and the best proven, is the upwelling system. However, the growth is not optimal using this system. We can successfully work with clams of 1 mm in size with this system. Upwellers need cleaning at least once a day. The outlet has a 4 inch (10 cm) elbow which allows control of the water flow rate.

A "box upweller" is good for larger volumes of product as it is easier to clean. There is also less plumbing used to set up a box upweller. These tanks have about a 12 inch (30 cm) inch inlet. Water flow is controlled by adjusting the elbow on the outlet.

We also have used Nestier and Mexican trays to raise small seed. The trays are lined with 1000 micron Nitex screen. The Nitex is glued into the trays with a hot glue gun. The clams are put into the trays and the trays are stacked 5-8 deep and secured together. About 10,000 clams can be grown in each tray to 6-8 mm size. These trays can be hung from rafts or placed directly on the beach in the lower intertidal zone. This is a good method to winter clams in low sediment areas. Poor circulation and slow growth are the biggest problems with this nursery method.

Another method that requires low maintenance for overwintering clam seed is a fine mesh "clam bag". Most mesh sizes require the use of 3-4 mm clam seed. I use a density of about 10,000 clams per bag. If these bags are placed on a shifting beach, they will fill with sand and the clams will die. I have had good luck with clam bags on muddy beaches. There seems to be very little mortality due to cold weather with this method.

We have also developed a floating upwelling system. It has bins of 40 inches square (0.3 meters square) and about 4.5 feet (1.4 meters) deep. These require some maintenance as the screen must be cleaned every day. We mostly grow single oyster in these but we have successfully nurseried bags of clams as well.

No matter the system you choose to nursery raise clam seed, the goal is to bring large numbers to a size suitable for planting, which is about 6-8 mm.

Question : What density are you seeding at?

The density that we seed depends somewhat on how many clam are already in the ground. Usually I plant seed at 40 clams per square foot (432 per square meter).

Question : What is the best method to overwinter clam seed?

I showed you all the methods we used. I was hoping you would work on it up here and let me know in a few years. We have chosen to use upwellers this winter.

Question : Is holding seed in rafts better than on the beach?

Each system I have told you about has it's advantages and disadvantages. Beach methods are possibly better for some, because less up front costs are involved.

Question : What temperature do you condition your clams at?

We usually condition at 19-21 degrees C.

Question : What temperature do you set your clam larvae at?

We run our larvae tanks at 27-28 degrees C.

Question : What size do you overwinter your seed at?

We try not to overwinter seed. Larvae is put in seed floats in the spring. Then it is usually planted out later in the summer.

Question : What are the water flow rates in your seed floats?

I do not know. But I do know that if you have a volume of water that is 18 inches (0.4 meters) deep and 8 feet (2.5 meters) wide, moving at a rate of 1 mile (1.7 kilometres) per hour, you need an awful big pump to match that amount of output.

HATCHERY TECHNOLOGY FOR PRODUCING LOW-COST MANILA CLAM SEED

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The study which I am going to discuss today was partially funded by a grant from the Science Council of British Columbia. Its purpose is to develop hatchery and nursery technology for producing cheaper Manila clam seed. My presentation will focus on the hatchery side of the project and later Mr. Scott Rempel, of Redonda Sea farms Ltd., will discuss the nursery phase of the study.

We are investigating various aspects of the development of clam broodstock, larvae and pediveliger larvae. We are working with Redonda Sea Farms Ltd. in the investigation and development of appropriate nursery technology to grow post larval clams to optimum outplanting size. The end result will be a "how to manual" detailing the methods we found successful and including descriptions of clam culture methods used in other places in the world.

The hatchery part of the project is being carried out in our hatchery at Lasqueti Island. We have done some work in the past on Manila clams but usually just when the natural spawnings were occurring. We had never before attempted out of season conditioning. Our past experience showed that clam larvae was more difficult to produce consistently than oyster larvae.

The broodstock conditioning trials compared "flow through" and "static" tanks. We used a matrix of temperatures and hormone treatment in order to speed up maturation. We learned that static tank conditioning worked best combined with heavy algal feeding. More work needs to be done on which species of algae are best for conditioning.

In our spawning trials we had 20 successful spawns during the summer. We tried seven different methods for inducing spawning. They included: heavy feeding with straight algae; thermal manipulation with cold and hot water; gonadal extract (adding eggs and sperm); ultra violet treatment of the water; seritonnin injections; and, hydrogen peroxide. We even tried, accidentally, mild electric stimulation. We found that the adults must be completely ripe to spawn and the best inducement was temperature shock with heavy algal feeding. Unfortunately the problems are not over once spawning starts.

We looked at three different spawning methods including: strip spawning; mass spawning; and, controlled spawning. Controlled spawning, which entails the separation of males and female to prevent overfertilization, worked best. Our best method was to continue to take males out as they spawned and to pump the fertilized eggs over into one of our 6,000 gallons (27,300 liters) larvae tanks so that they could develop into the straight hinged stage.

As the season progressed we had increasingly poor success although our first batch had almost 100% survival. We attribute the poor results to egg quality and plan to concentrate on developing conditioning methods that will give us optimally conditioned eggs through the entire season.

We also looked at rearing temperature and feeding rates and found that the best temperature seemed to be 21-23 degrees C. We fed the larvae a mixture of algae including: Tahitian *Isocrysis*; *Pablova lutherii*; *Isocrysis galbans*; *Thalassosira pseudonana*; *Skelotemma spp.*; *Chaetocerous calcitrans*; and, *C. gracillis*. In order to do this study we had to double our algae production capacity. We also did trials using algae paste as food, which they seemed to love.

The larvae rearing was usually done in 6,000 gallon (27,300 liter) tanks. We found the clams needed more frequent water changes than oysters so we changed the water every other day through a micron calibrated filter screen with meshes of 44 to 130 microns.

Once the larvae were on the 130 micron screen, they had reached the pediveliger stage and were ready for setting. There is no eye spot in clams at this stage but they are visibly ready to set when they reach out with their foot, examining the substrate.

We examined setting in the larval tank, on water tables and in downwellers. The water tables are made of a piece of plywood with a 2" x 4" edge and fiberglassed. This is my favourite as it gives them more surface to graze around on, they are easy to clean daily and it is easier to observe their actions. Larvae can be moved to downwellers using a water spray once they can stay on a 200 micron screen.

In a recent trip to Europe we had an opportunity to visit a number of hatcheries and to examine numerous types of nursery equipment. In France, Spain and the United Kingdom we found hatcheries using plastic 2 litre coke bottles as forced upwellers. The bottles are inverted, have their bottoms cut out and the water is forced up through the clam seed inside. The water flows out through a tube at the top. We found coke bottles are best suited to small clam seed ranging in size from 500 microns to 2 mm. They should then be transferred to high flow upwellers.

Clams grew well in the coke bottle upwellers but it was obvious that we required higher flows in our operation. In the upwellers the clams continually tried to climb the walls to escape. Each day the clams must be washed off of the sides while we clean the system.

The size of clam seed from the same spawning varies greatly in size. It will be interesting to determine how much of this we can selectively breed for.

As Mr. Paul Taylor reminded us, the purpose of our business is to put large numbers of clams on the beach. We hope that our study will provide growers with methods to produce those numbers at a lower price than is currently available.

Question : What is the method you use to clean upwellers?

We wash daily with fresh water but once a week we clean the tanks with Javex (chlorine bleach).

Question : Do you resort the clam seed during cleaning?

In this study we could not as we are involved with growth studies. Normally you would as clams sorted to equivalent sizes will grow better.

NURSERY CULTURE OF MANILA CLAMS

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In our project we compared the growth rates of seed clams at various densities (100 ml, 200 ml, 400 ml and 800 ml) using passive upwell and raceway systems. Our research year is divided into 6 two month periods and at this time we have completed two of these periods: June-July, and August-September.

Raceway System

The raceway that we used was a 5 foot (1.5 meters) wide by 10 foot (3.1 meters) long trough, which was roughly 2 feet (0.6 meters) deep. Water entered the raceway through a series of holes which had been drilled in 2" P.V.C. pipes which ran the length of the raceway. The clams were held in Nestier trays lined with window screening.

Passive Upwell System

The passive upwell system is basically a trough in which fourteen 5 gallon (22.8 litres) plastic buckets are suspended. The buckets had their bottom replaced with window screening. Water flows upward through the screen and clam mass and then exits through a syphon system, rather than traditional overflow.

Experimental Design and Results

When the experiment began we had a limited number of clams. As a result, only 100 ml volumes of clams were used for the first seasons experiments. The 100 ml volume is a useful base line by which to compare the effect of various densities of clams.

Growth was charted as an average increase in volume per day. Growth, as a function of the increase in standard length, was also measured but this will not be presented at this time. The volume of the clams was measured every second week.

An average volume increase of 5.5% per day in the upwellers versus 4.3% per day in the raceway was recorded in the initial 100 ml volumes for the period between June 29 and July 17. Between July 17 and 27, a volume increase of 6.9% and 4.3% per day was recorded for the upwellers and raceway respectively.

Between June 29 and July 27, a volume increase of 239% was recorded for the initial 100 ml volume of clams held in the passive upwellers. This increase in volume would be equivalent to an increase in standard length of between 2.3 mm to 2.4 mm.

The growth peaked in mid August at 12.4% and 4.8% per day for the upwellers and raceway respectively. The daily growth increments have decreased since mid August, and now stand at roughly 1% for the upwell system and 0% for the raceway system.

When we grew out the initial 200 ml volumes, the growth rates for the upweller grown clams were similar to the initial 100 ml volumes for the first two weeks. The growth rates then diverged slightly for the remainder of the experiment.

The growth rates of the raceway held clams of similar initial volumes, over the same time period, was markedly different at a daily increase of 4.8% per day for the initial 100 ml volume versus 2.5% per day for the initial 200 ml volume. For the remainder of the experiment the growth rates of the initial 100 and 200 ml volumes of raceway held clams were very similar. This early divergence indicates growth is being limited by the densities of the clams in the trays.

Growth in the raceways at the initial 400 ml volume peaked at 0.6% and is now at less than 0.1% per day.

With the initial 800 ml volume of clams held in the raceway, the growth rate dropped dramatically in the third and fourth week of the experiment.

Question : How do you relate the growth of the animals to the design of your system?

The system design is limited by water flow. In the raceway, for example, the limiting factor was the outflow. Therefore, we could not increase the flow in the raceways to the optimum without fear of flooding the facility.

Question : Did you heat the water or feed the clams?

We did not heat the water and the food was just that in the natural water off Squirrel Cove.

Question : Did you monitor the temperatures?

Yes. The temperature seemed to lag about a week behind the maximum growth rate.

MANILA CLAM HATCHERY TECHNOLOGY IN FRANCE

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We began our work to determine the scientific and technical possibilities of Manila clam culture in 1975. We eventually established a regional and national program and between 1981 and 1984 we developed an experimental hatchery. We received our initial broodstock for the hatchery from British Columbia and by 1986 we had produced approximately 400 tonnes of farmed clams valued at approximately 4.5 million dollars. This increased to almost 600 tonnes by 1987. Once we reached this point in our project we began to have problems with the commercial harvest. We began to have natural recruitment which originated from within France and from Italy. Because of the increased production, the market, which was mostly in Spain, became saturated.

In 1981 we had one hatchery in France and by 1986 we had 15. In 1990 we have around 10. We have now begun to have a problem with a pathogen called "Brown Ring Disease" .

The technology used in France is very similar to that used in B.C., but what is different is the water quality. For example, hatcheries are usually located in more estuarine water while our nurseries are situated in more saline waters.

Our basic hatchery design is similar to those I have seen in the United States. Water flows in through a sand filter and is heated through a fresh water/sea water titanium heat exchanger (this system was developed in about 1976 in France for the pasteurization of milk). The water is filtered with 1 to 5 micrometer filters.

In the hatchery we raise algae to feed the larvae. Common algaes are _Isocrysis galbana_, Tahitian _Isocrysis_, _Platymonas suecica_, _Pavlova lutheri_ and _Chaetoceras calcitrans_. We mature the clams at 18 degrees C. and feed at a level of 100-150 cells per microliter. For the most part we use similar methods for raising algae, however, we filter our sea water to 1 micron and sterilize with hydrochloric acid or hypochlorite. We sterilize for 12 hours with hydrochloric acid and aim for a pH of 7.0. In the open tubes we can achieve _Isocrysis_ or _Chaetoceras_ at densities of 10-20 million cells per ml.

We use small larvae tanks in France, 400-2,000 liters. We achieve metamorphosis in approximately 15 days at a temperature of around 23 degrees C. At this point we sort out on 80-100 micron mesh and the clams are metamorphosed in bags/trays/buckets at a density at 250,000 to 1,000,000 animals per bucket. We also use this technology for scallop metamorphosis. The larvae is put in cylinders with a 50 cm diameter and a height of 35 cm. Sea water is pumped in through the top as a downweller and food is dripped in at the same time.

Some growers use square concrete tanks converted into upwellers for their nursery system, however, cylindrical tanks are easier to clean. The juveniles are held in the nursery at a density of 20,000 per cylinder until they are 2-3 mm. The density is then decreased to 5,000-6,000 until they are 10-15 mm. The flow rate is maintained at 3 cubic meters per hour. In this type of system mortalities are low. The system is cleaned, at least initially, every two days until the clams reach approximately 1 mm. At that time the cleaning is reduced to twice a week. As the size further increases you can reduce cleaning to once a week or every two weeks.

Farmers also raise 1.5 mm juveniles they receive from a hatchery. The farmers use a bag and rack system at a density of 10,000-15,000 per square meter. When the seed reaches 4-5 mm, densities are reduced to 5,000-10,000 per square meter. The racks are usually set at the 1-1.5 meter tide height.

In the past few years we have developed newer and more efficient systems for use as clam hatcheries and nurseries. In one area we have developed facilities in which we obtain our sea water from artesian wells. The water from this source is clean, with no bacteria, and is at a constant temperature of 13.5 degrees C. The water is also nutrient rich with natural silicates, which makes an excellent water source for algae production, especially Skeletonema costatum. Our production is around 2,000,000 cells per ml in four days from an inoculum of 500,000 to 800,000 cells per ml. This well sea water has a high iron content so we do not use it for our nursery system except that we feed the juveniles with algae which is grown in the water. Five of the ten hatcheries in France use this system. The hatchery can also produce Crassostrea gigas and Ostrea edulis.

We seem to be able to grow the Manila juveniles to just under 15 mm in upwelling and flow through systems but after that size we find deformation of the shells. The shells grow more round, we say in France that they have a "big behind". Once this occurs they are unable to dig into the beach so prior to the clams reaching 15 mm, they are usually planted.

The clams are planted for grow out at about 3 mm in early spring in racks or in upweller cylinders and then planted out in March at about 12 mm.

Question : How large can you grow the juvenile clam in the bags on the racks intertidally?

You could grow them as quite large but as I mentioned our clams deform after 15 mm so we plant them out before they reach this size.

Question : What, in your opinion, causes the shell deformation?

We do not know. It may be a problems with mechanics or anatomy.

Question : At what size clam do you feed Skeletonema costatum ?

At all sizes.

NURSERY SYSTEMS AND JUVENILE CLAM FEEDING BEHAVIOUR.

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About ten years ago I began to preach to aquaculturists that it was risky to generalize from a single species to other bivalves. I think that the work done by Morton and Yonge early in this century set the stage for the oyster being used as a type species of bivalve, from which one could extrapolate to all other bivalves. The oyster is actually an unusual kind of bivalve in many ways. A couple of years ago I contradicted this philosophy by going to a giant clam workshop in Australia, and telling them what they might have a look at on the basis of work that had been done on Panope abrupta (our local "true" giant clam) at the University of Victoria. I would like to reverse that again by introducing you to giant clam culture and generalizing from it to the Manila Clam.

There are three species of Tridacna (giant clam) that are currently being investigated for aquaculture in Australia. They include: Tridacna maxima, T. derasa and T. gigas. The first of these may grow to between 800-1,000 kg and reach a length of one meter. They are symbiotic and can partially subsist on sunlight alone. Thus they have many atypical features. These clams are being cultured for market and for restocking depleted areas on the Great Barrier Reef and throughout the south Pacific. Animals produced in the fourth year of this program were sold in Japan for $50 per clam. Conversion to shakagai sushi increases each clam's value considerably.

The juvenile cultured clams are grown in raceways until they are large enough to hand-pick, and are then set out in cages at selected sites for grow out to market size. The juveniles of this genus are interesting in that immediately after metamorphosis, they show a behaviour common to most young bivalves, except oysters. Like Manila clam juveniles, for instance, they crawl about a great deal. The foot and labial palps are important to the clam in this phase: particles of deposit material are carried up the foot by pedal cilia and ingested after having been formed into a bolus between the palps. Another aspect of juvenile feeding behaviour found in the juveniles of many species is an activity whereby the clam lies upside down or on its side, projects the foot posteriorly, and swings it around through 180 degrees. The foot is then retracted. During this time the cilia are collecting particulate matter and carrying it up the foot to the labial palps. The heavier debris is centrifuged off by the circulating currents in the mantle cavity. This stereotypical pedal-palp feeding behaviour is found in many bivalves. It is, however, absent from scallops as far as we know.

Another type of feeding, that may not be generally known, is found in pisids (fresh water clams). The clam sits on the bottom and probes with its foot into the substrate. The foot apparently makes a subterranean cavity and any suspended matter which is in this cavity is carried up the foot by the pedal feeding mechanism into the region of the labial palps and mouth. This is referred to as interstitial suspension feeding. Giant clam juveniles seem to be able to do this.

So the three possible types of feeding mechanisms found in giant clam juveniles and possibly many other early juvenile bivalves are:

- locomotory and probing behaviour with pedal feeding;
- postero-anterior swinging foot feeding; and,
- interstitial suspension feeding.

In exceptional cases like oysters and pholads suspension feeding starts at metamorphosis.

My predictions concerning giant clam juveniles, that were fortunately borne out by direct observation a week after I made them, were based on work on the geoduck Panope abrupta which was part of a MSc thesis by Mr. Jeff King, under supervision by Dr. R. Burke at the University of Victoria. We can afford to generalize to some extent from these studies to the Manila clam. The long foot is highly ciliated, and a lot of particulate matter sticks to it. It anchors itself temporarily, by byssus, while it conducts the behaviours I have just described. Until the gills are properly formed as a filtration apparatus, juvenile bivalves are, generally speaking, confined to using pedal feeding behaviour as a means of sustenance because, even though the gill bars are present, they are not capable of a coordinated collection of suspended food. And there is no connecting foot groove from the margin of the gills directly to the mouth. In fact, the foot gets in the way of filtration in suspension feeders until the apparatus is properly formed (at around 12 weeks after metamorphosis in Panope).

We can conclude from these kinds of observations that there are several important factors in the critical stage between metamorphosis and the onset of the effective suspension feeding apparatus. For example, the way the food is presented to the juvenile must be important. The food must be on the bottom because the organism can only feed at the interface between the water column and the substrate.

If we want to look at this in applied terms the flow regime through the nursery must also be considered. If the flow is such that the food is constantly being removed from the location of the bivalve then obviously it will be illnourished. The percolation rate through the substrate is also important. These factors must be considered to discover the optimal nursery conditions to raise Manila clams.

With the help of a core STDF-AGAR B.C. Science Council Grant, the cooperation of Mr. Geoff Lindsay of Canadian Benthic Ltd. and the assistance of Ms. Kelly Bartlett, this project on "Juvenile Feeding Behaviour in Manila Clams" was undertaken at the Bamfield Marine Station. We have begun to verify that some of the above generalizations are true relative for the Manila clam, using pediveligers that we have set and exposed to different conditions of water flow and substrate type. Initially we concentrated on the stage of development lasting about three weeks, between metamorphosis and 600 micrometers. It is at that stage that the Manila clam seems to be able to suspension feed. But we have seen pedal feeding of the kind that I have described up to 1 mm in size. We have seen both the pedal probing and, to a lesser extent, the postero-anterior swinging of the foot. Probably pedal feeding of this kind continues to contribute to the economy of the Manila up to at least the 1 mm length.

To look at the flow regimes we devised a set of R.F.C.'s (reversible flow chambers) made very simply from 2" PVC pipe, with caps at each end. Set into the caps are Nitex screen to capture any juveniles that may try to escape. Unfortunately, the screen also captures any debris in the water. We had to determine what kind of substrate was most suitable for setting and early juvenile development. We do not have completely reliable statistics on this at the present, but we can generalize that a fine gravel and ground shell mixture (50:50) gives the best results and is the best substrate for juvenile growth.

Initially these studies only involved upwelling, which is more or less the traditional way in which water is delivered in Manila clam nurseries. In a second set of experiments we established several regimes:

1. an 8 day downwelling period followed by a continuous upwelling (traditional);

2. downwelling only for the entire period for two phases of 12 days each;

3. downwelling for 4 days, then downwelling with one hour of upwelling per day. We felt initially that one of the problems of continuous downwelling was going to be clogging of the screen with sediment, etc. So a one hour upwelling was introduced to remove accumulated sediments;

4. downwelling for 8 days, then alternative upwelling and downwelling for 12 hour periods; and,

5. a replicate of treatment # 3 (mostly downwelling with occasional upwelling) in which we added substrate as an additional variable.

The tentative results suggest that a downwelling regime is superior to an upwelling regime, even for large juveniles (<1 mm in length). We found that adding one hour of upwelling every 24 hour period was good because it solved the silting problem. The 12 hour alternating up/downwelling regimes gave the best survival rates (53%), including setting, and the best growth rates. These are the kinds of data that we are continuing to acquire and we are also investigating the population densities in these flow chambers. Our samples sizes have been 250,000 pediveligers in each chamber. We suspect that this may be overpopulated and we have to determine what the best population might be per volume of nursery chamber.

Nor do we know what the most appropriate flow level might be in reversible flow chambers. It has to be sufficient to keep things moving but not so great that the animals are constantly being stirred up and spending most of their time trying to get back to where they were comfortable and feeding. We also had problems with the pedivelligers' quality, size and vigour in each batch, which we cannot control since we are not raising them ourselves. Even if we were we would probably have the same difficulties.

Currently we are working with feeding regime studies, looking for the optimal regime for best growth and survival under the nursery condition that we have devised. We must also find out about the digestive cycle to determine the periodicity for feeding. If the digestive cycle is, for example, twelve hours or less, you should probably pulse-feed twice a day rather than continuously.

We have also tried numerous combinations of treatments to improve setting. We tried various concentrations of epinephrine, present or absent, with a variety of substrate types, and discovered that epinephrine is very effective at getting immediate setting but it does not necessarily follow that the survival rate is any better in the longer term. Survival better than 50% over twelve days, including setting, and good growth rates, suggests that we are well on our way in determining the optimal conditions for the development of the juvenile Manila clam.

Question : What substrate combination did you find the most effective?

We tried a 50:50 mix of finely ground oyster shell with sand. The sand was approximately 75 micrometers in diameter and the shell was about 120 micrometers.

Question : How long did the experiment run?

Twenty four or twenty·fivee days with subsamples taken at twelve day intervals.

Question : How often were your tanks cleaned?

We cleaned them daily. Our containers were very small, so they would not immediately satisfy commercial hatchery conditions.

Postscript : Since 2 litre plastic bottle upwellers are widely used with some success in Europe (refer to Hatchery Technology for Producing Low-Cost Manila Clam Seed by Mr. G. Jones in these proceedings), there should be little difficulty in upscaling our reversible flow chambers for commercial application.

PILOT-SCALE CLAM SEEDING AND HUSBANDRY TRIALS IN B.C.

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This presentation is a synopsis of the paper recently published by the Ministry entitled "Pilot-Scale Site and Husbandry Assessment for Manila Clam Culture" (Aquaculture Factsheet No. 34 B. Roland, K. Albrecht and T. Pobran, 1990). It provides information on how to assess specific sites and husbandry techniques on a pilot-scale. Methodology is illustrated by describing the set-up and preliminary analysis of the results of a clam grow out study initiated by the Ministry in June, 1989. Results from such an assessment can then be evaluated and used to make decisions about future commercial development.

Specific questions addressed by the Ministry project were:

1. Is there valuable information about siting to be gained from a preseeding inventory of clam stocks that uses clam size and age frequency to estimate growth rates, and density to estimate levels of natural recruitment?

2. Does seeding juvenile clams at either of two densities versus relying totally on wild set for production significantly increase yield?

3. Does covering of seeded and unseeded beach with car cover netting or a dense cover of oysters exclude predators or enhance natural recruitment?

Set-Up, Materials and Methods

Site Description

The site chosen was Deep Bay, Baynes Sound. Natural Manila clam stocks exist there which are commercially harvested. The substrate at the 6 foot tidal level is a mixture of gravel, sand and mud.

Experimental Design

Seven different treatments were investigated. Each treatment was replicated once in each of the three rows of plots. Each plot was assigned randomly to one of seven locations within each row. Each plot was 4 meters by 4 meters and separated from all other plots by a 1 meter wide path to allow access and to minimize the effect of plots on one another. The seed were obtained from Canadian Benthic Ltd. and were 6-8 mm in shell length. Oyster cover consisted of a dense (120-150 oysters per square meter) layer of 6-10 cm oysters. Net cover consisted of 3/4" x 5/8" car cover firmly attached to 1 pound per fathom lead line with electrical tie wraps. Thus each row or block contained these treatments:

Seed	Net Cover	Oyster Cover
1. yes (200 per square meter)	yes	no
2. yes (200 per square meter)	no	yes
3. yes (200 per square meter)	no	no
4. no	yes	no
5. no	no	yes
6. no	no	no
7. yes (400 per square meter)	yes	no

Sampling for Clam Stocks and Effects of Treatments

Each of the 21 plots were sampled prior to treatment. This allowed natural stocks to be documented and the effect of the treatments ascertained. The quadrat used was a 5 pound coffee can cut through the center. It has an area of 0.0181 square meters, or 181 square cm. The sieve was constructed of wood, about 0.01 square meter in area, with 1/4" stiff Vexar screen attached to the bottom.

Sampling for clams within each plot involves:

1. Visually dividing each plot into a grid with nine equal sections and dropping the quadrat with eyes closed within each of the sections.
2. Working the quadrat into the beach, removing the substrate to a depth of 15 cm with a trowel and placing this into the sieve.
3. Sieving the sample in a tub of sea water to remove mud, making the small and large clams visible upon sorting through the gravel, etc. by hand.
4. Pooling the clams from each plot. The shell lengths are measured and the growth checks (annuli or rings) counted and recorded. The first check is typically formed when the clams are less than 10 mm because the clams set during the summer and have less than a full season to grow. This check can be seen in small clams but as clams approach market size, the umbo is often eroded and the check gone. For these clams, assume that a check would have been present and add one to the count of visible checks.
5. Replacing the clams and substrate into the holes.

Seeding

The nursery indicated that there were 18.47 seed size clams per ml, based upon a 50 ml count. The seed are usually proportioned on a volume basis but because of the small volume involved we decided to proportion on a weight basis. We estimated from four counts that 50 seed weighed 2.57 grams, which works out to be 19.4 clams per gram. Thus the plots seeded at 200 per square meter received 164.5 grams and the plots at 400 received 329 grams of clams. The seed were spread as the incoming tide covered the plots. If spread too soon the top shell dries, the animals desiccate and, being very light, are picked up by the surface tension of the water. Only a few clams were observed being carried 1 or 2 meters before sinking.

To prevent this desiccation some people immerse the seed in sea water for 15 minutes which allows them to take up water, thus becoming heavy and able to break the surface tension of the water.

Data Analysis

At this point data have been collected prior and after the seeding. The data can be analysed to answer the three questions posed in the introduction.

Results and Interpretation of the Deep Bay Project

Question 1. What can be learned about the site from a preseeding inventory?

Estimation of growth rates and recruitment required that the data from the preseeding inventory on shell lengths be grouped by the number of growth checks. To do this the data from the three unseeded and unprotected (unaltered or control) plots were pooled as shown in Table 1.

Table 1. Lengths of clams ordered by the number of growth checks, and resulting summary statistics on number per age class, average length and weight.

	Number of Growth Checks					
	1	2	3	4	5	6
Lengths	7	21	36	34	35	39
	16	21	23	38	36	37
	12	16	28	38	36	41
	etc.	etc.	etc.	etc.	etc.	etc.
Total # in group	21	25	15	22	18	11
Average Length (mm)	13	19	28	32	36	39
Weight (grams)	.42	1.4	4.5	6.9	9.9	12.7

This analysis indicates that grow out of a minimum legal size clam of 38 mm would take about 5 years from settlement or about 4 years from seed.

From this analysis the average growth per year is the difference in size between groups or age classes (Table 2).

Table 2. Annual growth rate of Deep Bay clams.

	Age Class (years)					
	0-1	1-2	2-3	3-4	4-5	5-6
Annual Growth Rate (mm)	13	6	9	4	4	3
Annual Growth Rate (g)	0.4	1.0	3.1	2.4	3.0	2.7

The growth rate, as measured by length, decreases as the clams grow older. The growth rates at this site are fairly slow. Note that a small change in length of larger clams represents a relatively large change in weight.

Estimation of the number of clams in each age class can be made by converting the total numbers in each group in Table 1 into numbers per square meter. These data are pooled samples of clams from three replicate plots, each of which were sampled nine times with a 0.0181 square meter quadrat. Thus the pooled samples represent 0.49 square meters, so multiplying the total for each group by 2.04 will convert the numbers to density per square meter (Table 3).

Table 3. Number of clams per square meter by age class.

	Age Class (years)					
	0-1	1-2	2-3	3-4	4-5	5-6
Number per Square Meter	43	51	31	45	37	23

All year classes are approximately the same density except for the harvest sized animals in the 5-6 year group. Many of these may have been recently harvested as the area is dug by permission of the lease holder. Natural seeding may provide 30-50 clams per square meter per year (1-1.5 pounds).

Questions 2 & 3 : Can production of clams at Deep Bay be enhanced by seeding or predator deterrence?

The answers to these questions are facilitated by production of Table 4. As the seed were still small, only the portion of the table covering the smaller sizes needs to be examined.

The table shows that most of the seeded clams are included in the 5-20 mm size classes. The 21-25 mm clams represent clams that were in the beach prior to seeding.

Table 5 analyzes seed survival by summing the averages in the 5-20 mm size classes. The number of clams in the control plots (unaltered or protected) are subtracted from these altered (seeded and/or protected) plots. The difference is the number of additional clams that were produced by seeding. The appropriate control plots for the various treatments are:

Treatment	Appropriate Control
car cover only	control (unaltered)
oyster cover only	control (unaltered)
seed only	control (unaltered)
oyster cover + seed	oyster cover only
car cover + seed	car cover only

Seed survival is estimated by dividing the number of additional clams by the number seeded per square meter. The calculations required are shown in Table 5.

Table 5. Summary of the preliminary results of enhancement efforts for Manila clams at Deep Bay in March, 1990.

Treatment	Number per Square Meter in Size Classes by Shell Length (mm) 5-10	11-15	16-20	Sum	Number Over Control	Percent Survival of Seed
Control	12	29	24	65	n.a.	n.a.
Car Cover Only	18	12	27	57	-7	n.a.
Oyster Cover Only	18	27	29	74	+9	n.a.
200 Seed per Square Meter	14	135	100	249	+184	92%
Oyster Cover + 200 Seed per Square Meter	41	59	43	143	+69	35%
Car Cover + 200 Seed per Square Meter	16	119	47	182	+125	63%
Car Cover + 400 Seed per Square Meter	25	256	49	330	+273	68%

Table 4. Number of small Manila clams per square meter at Deep Bay in March, 1990.

NUMBER OF MANILA CLAMS PER SQUARE METER IN SIZE CLASSES BY SHELL LENGTH (MM)

treatment	5-10	11-15	16-20	21-25	sum of 5-20 mm
control (unaltered)					
#1	6	12	37	37	55
#2	18	43	18	49	79
#3	12	31	18	18	61
average:	12	29	24	35	
car cover only					
#1	12	6	37	68	55
#2	25	18	25	43	68
#3	18	12	18	12	48
average:	18	12	27	41	
oyster cover only					
#1	12	49	37	0	98
#2	12	0	0	24	12
#3	31	31	49	31	111
average:	18	27	29	18	
200 seed per square meter only					
#1	31	135	104	25	270
#2	0	135	98	31	233
#3	12	135	98	37	245
average:	14	135	100	31	
oyster cover + 200 seed per square meter					
#1	18	37	74	37	129
#2	61	97	37	25	195
#3	43	43	18	18	104
average:	41	59	43	27	
car cover +200 seed per square meter					
#1	18	160	55	25	233
#2	25	98	61	55	178
#3	6	98	25	18	142
average:	16	119	47	33	
car cover +400 seed per square meter					
#1	25	166	80	25	271
#2	25	332	43	31	400
#3	25	270	25	80	320
average:	25	256	49	45	

Clearly, in the short period of July, 1989 to March,1990, the car cover and oyster cover did not enhance recruitment or survival of seed size clams. The seeding did significantly add to the number of seed size clams. Survival of seed in the plot with oyster cover was the lowest of the seeded plots. Possibly the oysters attract predators by providing cover while the tide is out or causing the clams to move closer to the surface. Either occurrence could increase predation. Survival in the plots with car cover was good (60-70%) and, not surprisingly, the 400 per square meter seeding had significantly more seed than any of the other treatments. The unprotected, seeded treatment had comparable survival (p=0.07) to the seeded treatment with car cover.

These results are intended to illustrate the kind of data that can be acquired. These data were collected only 8 months into a 3-4 year project and drawing conclusions, other than that the seed survival is encouraging, would be risky.

Growth of the seed in the plot covered with oysters seems slower than the other seeded plots. This is evident by the greater number of seed present in the 5-10 mm class. Possibly there is competition for the same food source. Most of the seed in the other plots were in the 11-15 mm size class. The seed grew from 6-8 mm to 11-15 mm from early June to March.

This analysis is intended only to illustrate how to analyse experimental data. The value of specific treatments should not be surmised from the present analysis because the experiment has not progressed far enough to make definite conclusions.

Additional Work

This investigation formed the basis of another study started in May, 1990 which studied growth and survival at six different sites. At this point in time there are no results to report. The six sites include: Sooke Harbour; Barkley Sound; Baynes Sound; Nanoose Bay; Cortes Island; and, Okeover Inlet. The variables being studied include two tide heights, seeding at 200 and 500 per square meter under car cover, cover without seed and bare beach. The results of this study will require several years to obtain and maintenance of the project should include reseeding yearly to estimate carrying capacity. The study should also determine the effect of yearly harvest - at least at selected sites.

ECONOMIC ASSESSMENT OF CULTURING THE MANILA CLAM IN B.C.

Mr. Lorne Clayton
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In 1990 we applied for and received funding from the Science Council of British Columbia to study the "Economic Assessment of Manila Clam Culture in British Columbia". However, as you can appreciate, the clam population which we are assessing has only been in the ground for less than four months so at this time it is premature to consider the economics of such a practice. I would like to detail the process with which we established the study and planted the seed on the study plots.

The study was funded in total by the Science Council of British Columbia, IEC Collaborative Marine Research and Development Ltd. and B. and J. Shellfish (Mr. Bill Markin). The specific objectives of the study are to:

- implement the Washington State recommended Manila clam culture technique into a representative clam culture site which is presently fished commercially;
- evaluate the effect this culture technology has upon natural recruitment rates of Manila and littleneck clams;
- evaluate the economic viability of commercial clam culture in British Columbia based upon the recruitment, growth and survival rates documented in this study; and,
- assess the potential disease transfer with the importation of clam seed from Washington State.

To accomplish these objectives we felt we had to establish a study plot, on a commercial clam beach, the size a clam farmer would be likely to seed. The site we chose was located in Baynes Sound on a tenure owned and operated by Mr. Bill Markin (Figure 3). The substrate varied from firm muddy/sand to cobble. The tide level over the study plot ranged from 1.5 - 2.76 meters (5-9 feet). The beach contained naturally occurring Manila clams populations. One additional requirement of the study site was that it be monitored easily and continuously as other experimental plots in the area had been vandalized.

Two plots, of one-quarter hectare each, were placed under 3/4" x 5/8" "car cover" net and seeded at a density of 200 seed per square meter, in keeping with the minimum seeding requirements of the Ministry of Agriculture and Fisheries (M.A.F.). Another two one-quarter hectare plots were set aside as controls. As the control plots were larger than we required for statistical purposes we established, within the

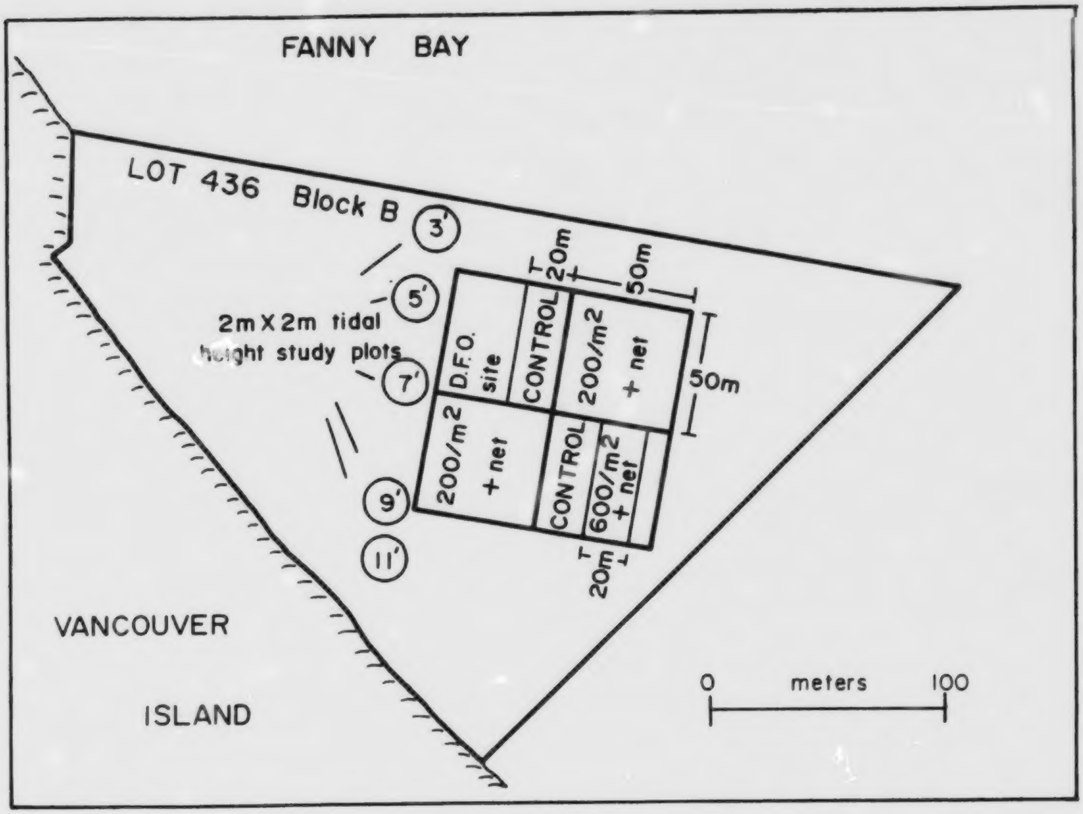

FANNY BAY
LOT 436 Block B
3'
5'
7'
9'
11'
2m X 2m tidal height study plots
D.F.O. site
CONTROL
200/m2 + net
20m
50m
50m
200/m2 + net
CONTROL
600/m2 + net
20m
VANCOUVER
ISLAND
0 meters 100

Figure 3. Geographic location and study design.

control plots the following additional study plots:

- one plot seeded at a density of 600 seed per square meter;
- a tide height study which monitors survival and growth at the 1, 1.5, 2.1, 2.76 and 3.38 meter (3,5,7,9 and 11 foot levels); and ,
- a study to examine the effects of digging on seed survival being carried out by Dr. Neil Bourne and Mr. Dwight Heritage of the Department of Fisheries and Oceans

To begin the study we carried out our regular beach inventory assessment. This entails developing a sampling regime applicable to the site. Using a quadrat, substrate samples are taken and sifted through a series of screens. Target clam species are removed and appropriate measurements such as shell length, shell width and wet weight are taken. This information is analyzed and plotted as shell length versus frequency. This information will often indicate the number of year classes present and whether stunting of clams has occurred.

The lease was dug commercially prior to netting, to replicate what we expect would be the normal course of events on a clam farm. Commercial sized clams were removed and sold by the lease holder, undersized clams were moved to an portion of the lease adjacent to the study plots. In most cases the clams had redug into the substrate within twenty-four hours.

To prepare the net it was cut into panels 5 meters by 50 meters. Marine 1 pound per fathom lead line was attached to those portions of the net that would be placed at the perimeter of the entire plot once deployed. The lead line was attached to the net with electrical ties, however, other methods are also applicable. The panels were rolled up individually and transported to the beach.

One end of the panel was fixed using staples that were constructed of 3/8" rebar bent into a "U" shape, which we have termed a rebar staple. The panel was then unrolled down the lease and fixed in place using the same method. Lengths of 5/16" poly rope were tied between two adjacent panels in order to add strength to the structure. Rebar staples were placed around the perimeter of the plot and along each margin where the nets were joined. Three people assembled each of the one quarter hectare plots in three hours.

The seed for this study were obtained from Kuiper Mariculture Inc. of Bay Side, California as they had the volume of seed we required. After determining the "disease free" status of the seed, a permit was obtained and the seed was flown from San Fransico to Comox Airport. Redonda Sea Farms Ltd. cleared the seed through customs in Vancouver for us.

The majority of seed we received was between 6-8 mm in size. We completed a number:volume analysis to determine the number of seed per unit volume. This was required as we planted the seed by volume per area rather than by direct count or weight. An important step in the process is to place the seed in sea water for a few minutes before you carry out volume determinations as clam seed will take on water and the volume will increase thus changing the number:volume ratio.

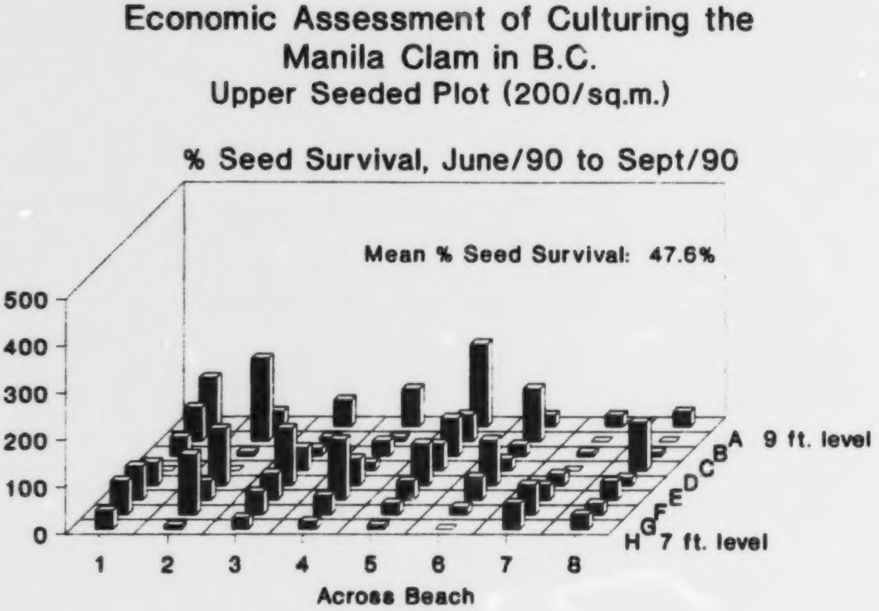
Prior to seeding the beach it should be well marked. In the study which we have undertaken for M.A.F., for example, we placed coloured flagging tape at one meter increments on the perimeter of the net. In the Science Council study we marked parallel edges of the 50 m by 50 m plot every 2 meters with painted rebar rods. We ran a rope from one side of the plot to the other like a transect line.

The seed was portioned out into buckets of sea water, with enough seed to cover one of our 2 meter by 50 meter subplots at a rate of 200 seed per square meter. Starting at one end of the plot (the lowest tide level) we seeded one subplot. Our transact rope was moved to the next set of rebar poles and that corridor was seeded. As we had four people seeding, we had two such transect lines with which we "leapfrogged" our way up the beach. The seed was spread by trickling it out through our fingers just as the water level reached the spot within the plot. Four people seeded one quarter hectare plot in one and one half hours. All the clam seed dug into the substrate within ten minutes of being seeded.

Of the 6-8 mm seed we planted in the second week of June, some had reached 15 mm by the second week of September. Survival of the clam seed increased as we moved up the beach, to a point, then it fell off. This may be a function of substrate type and therefore it is premature to suggest that survival would normally decrease at these heights. A three dimensional graph of the plot shows that the survival from even one sample to the next varies widely (Figure 4 & 5). Survival in this area ranged from 0 to 500%. We believe the 500% survival is the result of a spilled bucket of clam seed. The 0% survival may be a function of a large rock taking up much of the sample area.

Summary of results show that the mean survival or recovery rate of the planted seed in the lower plot is 44.00% while in the upper plot it is 47.63%, for an overall survival, or recovery rate, of 46.40%.

We look forward to continuing the study and being able to statistically analyse our data which we will make available to industry and governments at future workshops.



Economic Assessment of Culturing the Manila Clam in B.C.
Upper Seeded Plot (200/sq.m.)

% Seed Survival, June/90 to Sept/90

Figure 4. Planted Manila seed survival rates in relation to sampling quadrat in upper seeded plot.

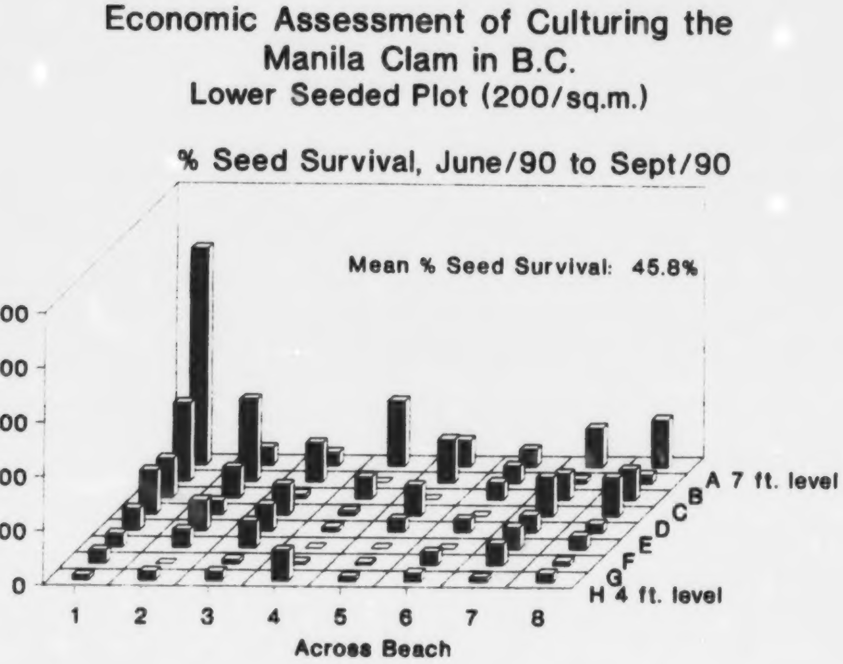


Figure 5. Planted Manila seed survival rates in relation to sampling quadrat in lower seeded plot.

PANEL DISCUSSION

Ms. Christine Hodgeson	North Island College Moderator

Question : How reliable is determining the age of the clam by counting growth checks?

Mr. Bill Roland : Ministry of Agriculture and Fisheries (M.A.F.)

According to Dr. Bourne, the method is reliable most of the time, however, digging and replanting clams may add another check. The data from our experiments to date, in which we know the age of the clam from the hatchery, seem to verify this method. We will know further as we trace these clams through their life cycle.

Mr. Paul Taylor : Taylor United Inc.

Growth checks are put on primarily on a yearly basis but I have seen the clams put on a growth check through the stress of transplanting. So the growth check may be more of a stress check and every winter clams are stressed.

Question : How long is it going to take us to grow a marketable clam in Canada?

Mr. Paul Taylor : Taylor United Inc.

In Puget Sound it takes about three growing seasons to get a legal sized clam. But this varies even within a bay a few miles apart.

Mr. Doug Thompson : Washington State Fisheries

On a gravel plot in the South Sound I have seen clams grow from 2 mm to 24-25 mm in one growing season.

Question : Have you been able to transfer "stunted" undersized clams from a higher tide level to a lower tide level to increase growth?

Mr. Paul Taylor : Taylor United Inc.

I know that on Hood Canal, clams never do reach commercial size (38 mm) on the upper levels of the beach. Some clams that are very old never seem to grow even when moved down the beach. I suggest that you move some of yours and test your results.

Question : Based on you experience what is the optimal seeding density to use on a beach, the optimal time of year to seed and the best size of seed to plant?

Mr. Paul Taylor : Taylor United Inc.

I usually target on a particular beach's maximum ability to grow clams. This is about 40 clams per square foot (432 per square meter). If you seed too much, the beach will reach its maximum production and then slow down, due to competition. I like to plant 6-8 mm clam seed in the spring as it is likely to grow all summer and be of a size less susceptible to predation by the fall

Question : To what extent are your clam beds covered by net?

Mr. Paul Taylor : Taylor United Inc.

Approximately 10%. That too is very site specific. For example, in some bays I have to cover everything while in other areas there does not seem to be predators.

Question : Do you use clam bags for grow out?

Mr. Paul Taylor : Taylor United Inc.

I have played with bags but they are expensive and a lot of work as compared to just enhancing the bottom.

Question : Do you find that birds are a big predator?

Mr. Paul Taylor : Taylor United Inc.

I don't think that seagulls and crows are big predators. I have seen these birds take a few clams but nothing significant. Black scoters, however, can devastate a beach. This is also site specific.

Question : Since your last trip to Canada have you determined, for your operation, your cost of production and your profitability of Manila clam culture?

Mr. Paul Taylor : Taylor United Inc.

No I haven't. I can tell you that it works. In a lot of my ground I am getting to the maximum carrying capacity. I have some experiments going on now to help me figure out the answers to those questions. I will know the answers in another two years.

Question : What type of wages do your diggers take home?

Mr. Paul Taylor : Taylor United Inc.

Generally they take home between $20,000 and $30,000 (U.S.) per year.

Question : Have you experimented with various sizes of net meshes?

Mr. Paul Taylor : Taylor United Inc.

Yes I have. I have gone to a 5/8" x 3/4" net as a lot of my ground silts up if I use a size smaller than that. I feel that a 1/2" mesh provided the best predatory protection, however, it can only be used on a low sediment lease. On some of your beaches here I would use 1/2" mesh.

Question : Mr. Roland in your talk a figure showed a better survival without car cover, what does this show?

Mr. Bill Roland : Ministry of Agriculture and Fisheries (M.A.F.)

The average survival of clam seed without protective car cover was 92% while the average survival of clam seed with protective cover was 63%. The level of variation between the plots is sufficient that we cannot conclude with great confidence (that is according to conservative scientific convention be at least 95% certain, p less than 0.05) that the treatments actually produced different results or are "significantly different" from a mathematical statistics point-of-view.

The level of variation is not likely due to sampling error within each plot. When the project was set up, it was determined that 9 samples estimated the number of clams in the plot as well as 16 samples. The source of variation lies in an inherent problem with agricultural field studies. The problem is that the stock are grown on different pieces of land that are only similar, not identical. And, because treatments are randomly assigned to plots, due to the luck-of-the-draw they may be assigned to plots that are inherently inferior. If there were time, money and beach space to use more than 3 plots, say 6, these differences would be more likely to even out, and give us more certainty about the effect of the various treatments. At any rate if the differences between the treatments is real then it should become increasingly evident over the next 2-3 growing seasons and be picked up by the once or twice yearly sampling.

It would be difficult, however, to explain why car cover decreased survival. If there really is no difference in survival with or without car cover on this beach at this time that would not be surprising simply because the predators may not have been present. Also consider that if car cover is not necessary at this site it may be necessary at another site due to differences in predation, and also consider that predator abundance fluctuates over years and predators, such as diving ducks, can learn about food sources. Without several years of site specific experience about predation I view car cover as insurance against predation losses.

Question : Mr. Clayton you mentioned that you planted when the water was a few inches deep while I have always seeded dry. Why did you choose to seed wet?

Mr. Lorne Clayton : IEC Collaborative Marine Research and Development Development Ltd.

We did this for two reasons. One, we were worried that if the clam seed landed on a rock it would crack. We only saw shore crabs eating clams that had already been cracked. Second, we seeded on a day when the air temperature was around 25 degrees C. and there was a breeze. We worried that the clams would dry out before the tide cam in and the clam seed would actually float away on the water interface. To solve these problems we seeded when the water was a few inches deep. I should point out, however, that the study area covered a significant tide range which meant we had the time to wait for the tide. On beaches of a constant tide level the tide would come in too fast and you, most likely, would not have the time required to seed the beach as we did in our study.

Question : Do you have problems with ghost shrimp?

Mr. Paul Taylor : Taylor United Inc.

We have found that clams do not do as well in areas where ghost shrimp are found.

Question : It seems to me that the study conducted by Mr. Bill Roland, of M.A.F., is going to generate some important information for the industry. I wounder what kind of assurance M.A.F. can give us that the work will continue?

Mr. Jim Anderson : Ministry of Agriculture & Fisheries (M.A.F.)

I suspect that even with a 5% budget cut we will able to sustain it next year, for sure. Clams are one of the priority species we have identified.

SUBSTRATE ENHANCEMENT OF CLAM BEACHES IN WASHINGTON

Mr. Doug Thompson

Washington State Department of Fisheries
Point Whitney Shellfish Laboratory
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98320

Introduction

In my talk today on the development of Manila clam habitat I will review clam production at existing enhancement sites and factors which have affected production at those sites. New site selection criteria and the recruitment and survival of Manila seed clams at our most recent gravel project will also be discussed.

I would like to preface my talk by briefly explaining why the Washington Department of Fisheries (W.D.F.) has initiated a Manila clam enhancement program. In Washington State, the fishing effort on Manila clams by recreational and tribal harvesters has increased approximately three times over the past five years. During this same time period, there has been a corresponding loss of productive clam habitat through pollution of public shellfish beds.

The Department believes that clam seeding is necessary to maintain the present rate of clam harvest on non-polluted beaches and that new clam habitat needs to be developed to replace beach area that has been lost to pollution. Through these enhancement efforts, the Department hopes to meet harvest demand and protect shellfish stocks without implementing restrictive closures or bag limits.

One method to create habitat is by "beach gravelling". Beach gravelling is the placement of gravel, or a mixture of gravel and crushed oyster shell, on a mud or mud-sand beach that does not naturally produce a significant population of clams. The gravelling process adds protection and creates interstitial space and substrate stability which provides an environment for newly settled Manila clams. Crushed shell keeps plots from compacting and provides calcium which may improve natural recruitment and may buffer low pH.

Existing Gravel Plots

Since 1974 W.D.F. has been involved with the development of several one acre test plots, one in Willapa Bay and the rest located in southern Puget Sound. The plots were surveyed for clam abundance in 1985 and 1988 (Figure 6).

A number of factors which may affect clam production have been identified. The most important factor is for plots to be in an area of high natural recruitment. Willapa Bay had the best results as it is located near a large population of Manila clams which spawn annually, providing the plot with significant levels of natural recruitment.

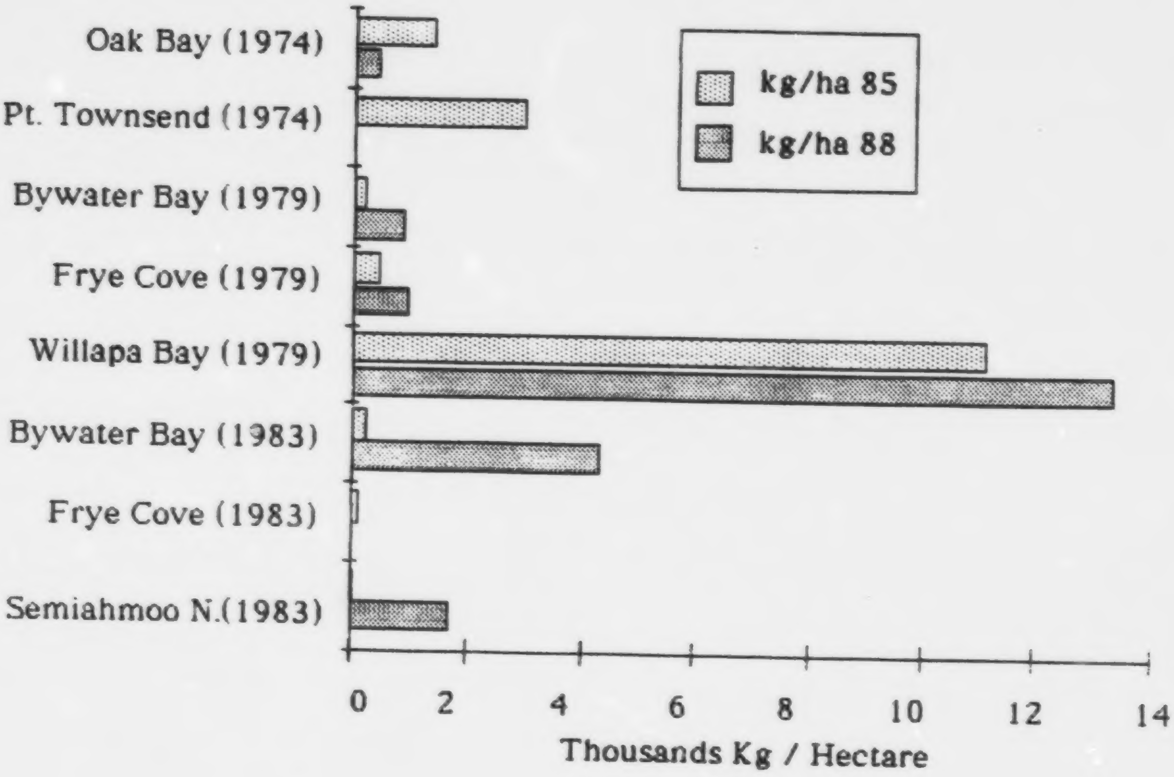

Figure 6. Estimated production on W.D.F. gravel sites.

Gravel type and size is also critical. Most success has been found with small, rounded gravel of a non-uniform size 0.6-1.9 cm (1/4"-3/4") in diameter. This gravel size provides the right amount of interstitial space necessary to collect the finer sediments required by setting sized clams. Angular gravel was found to compact easily, eliminating any interstitial space. Larger, cobble size gravel had too much interstitial space and was too porous to collect fine sediments.

Thick layers of gravel can smother many infaunal organisms and macro algae. The organisms eventually die and decay producing anaerobic conditions and the generation of hydrogen sulphide gas which lowers the pH, making the plot toxic to juvenile clams. Thick gravel layers also take longer to trap fine sediments which provide places for clams to set. Sites with gravel layers from 0.3 - 1.0 m (1.0 - 1.5 feet) thick have taken 8 to 15 years to produce clams.

Commercial growers in South Puget Sound have found that by adding multiple thin layers of gravel, from 2.5 - 15.0 cm (1.0 - 6.0 inches) thick, over a one to two year period cause the plots to become productive at a much quicker rate. By spreading only a thin layer of gravel at a time, the impact to organisms already present in the substrate is lessened.

Exposure is also important. At some of the more exposed sites we have found that wave action and longshore currents have caused gravel to shift into berms which are now too high to support good clam growth. Sites adjacent to seasonal streams or creeks have been eroded or covered with sediment.

Predation by moon snails, crabs and fish has limited production on plots established below +0.6 m (+2 foot) MLLW (see Editor's Note).

Site Selection Criteria

After examining these results we have developed a number of criteria which assist us in selecting new sites for successful enhancement. These criteria include:

Substrate Base and Beach Slope - gravel bonds to soft mud and this substrate is selected over hardpan or seasonally shifting sand substrate. Gradually sloping beaches hold gravel better than steep beaches and beaches with slope gradients greater than 1-2% are not selected for gravelling.

Natural Recruitment - selecting beaches within the optimal tidal range for Manila clams and close to naturally occurring clam beds increases the chances for natural clam sets. For Manila clams the optimal tide height for good growth and survival is between +1.0 and +2.0 m (+3.0 and +6.0 foot) MLLW (see Editor's Note).

Exposure - we select sheltered sites which have a low to moderate exposure to wave action and longshore current. If we are unsure of foreshore processes, we hire a professional consultant to examine the site. Based upon their recommendations the site is then approved or removed from consideration for gravelling.

Eelgrass and Macro Algae - eelgrass is a critical nursery habitat for juvenile salmon and for this reason gravel placement is restricted to no closer than 25 m (80 feet) to existing eelgrass patches. We also avoid areas with large concentrations of macro algae which would die and create anaerobic conditions.

Permits for gravelling are granted by various federal and state agencies, including W.D.F.. When applications for gravelling permits are made, W.D.F. acts as lead agency and each gravel project is first reviewed under the S.E.P.A. (State Environmental Protection Act) checklist for impacts to all species, habitat, archeological and historical sites. The permit process then proceeds with agency review allowing for public and tribal input.

As an example, when we applied for a gravelling permit at Oakland Bay, there was concern that gravel would negatively impact the micro crustacean component which provides a food source for juvenile salmon. After a three year study we found that gravelling actually improved the population of micro crustacea by increasing surface area of habitat. Both the diversity and abundance of organisms in the area increased.

Oakland Bay

Oakland Bay was selected for an initial test of these selection criteria. It is a soft mud beach that has a gradual slope and is well protected. We are comfortable with gravel size, tide heights, beach substrate and exposure. We are testing different compositions of crushed oyster shell and gravel, layer depth, multiple layering and gravel spreading techniques.

A 2 acre gravel plot was established in February of 1989. Compositions of 100% gravel and a 50:50 ratio of gravel and crushed oyster shell are being tested at thicknesses of 10.0 cm (4.0 inches) and 2.5 cm (1.0 inch) to determine the best composition and initial layer thickness for clam production.

To look at the effects of multiple layering a 2.5 cm (1.0 inch) layer of gravel will be added to one half of each of the 2.5 cm (1.0 inch) thick sections. This quantity of material will be added every six months to a year, until a sufficient depth is built up to support harvestable size clams. The most economical method of multiple layering is to identify the thickest possible layer that can be applied without causing the problems identified earlier.

To keep heavy equipment off the beach, gravel and shell were barged to the Oakland Bay site and spread over the area of the plot by a crane and dump bucket at high tide. This technique was satisfactory for spreading large quantities of gravel, up to 800 cubic yards, but the layering was uneven and thicker in some areas of the plot than the required depths. Also, when the shell and gravel mix was applied in this manner, the heavier gravel dropped to the bottom first leaving the shell on the surface of the plot rather than remaining mixed.

A more appropriate method of spreading gravel may be to wash the gravel off of the barge using a high pressure fire hose. The method is very practical for applying thin, even layers of gravel and avoids the gravel landing in piles on the beach. Our engineering section is also developing an automated device for spreading gravel.

We sampled the test plots in September 1989 and August 1990 to estimate abundance and survival rates for the 1989 year class of Manila clam seed (Figure 7).

In 1989 all treatments had nearly the same level of natural recruitment. Population estimates ranged from 1,500 to 1,830 seed per square meter (135 to 165 per square foot). In 1990 population estimates ranged from a low of 200 clams per square meter (18 clams per square foot) on the 2.5 cm (1.0 inch) gravel shell plot to a high of 890 clams per square meter (80 clams per square foot) on the 10.0 cm (4.0 inch) gravel plot. Seed survival was best on the 10.0 and 2.5 cm (4.0 and 1.0 inch) gravel plots with values of 48.2% and 45.6% respectively. The 10.0 and 2.5 cm (4.0 and 1.0 inch) shell gravel

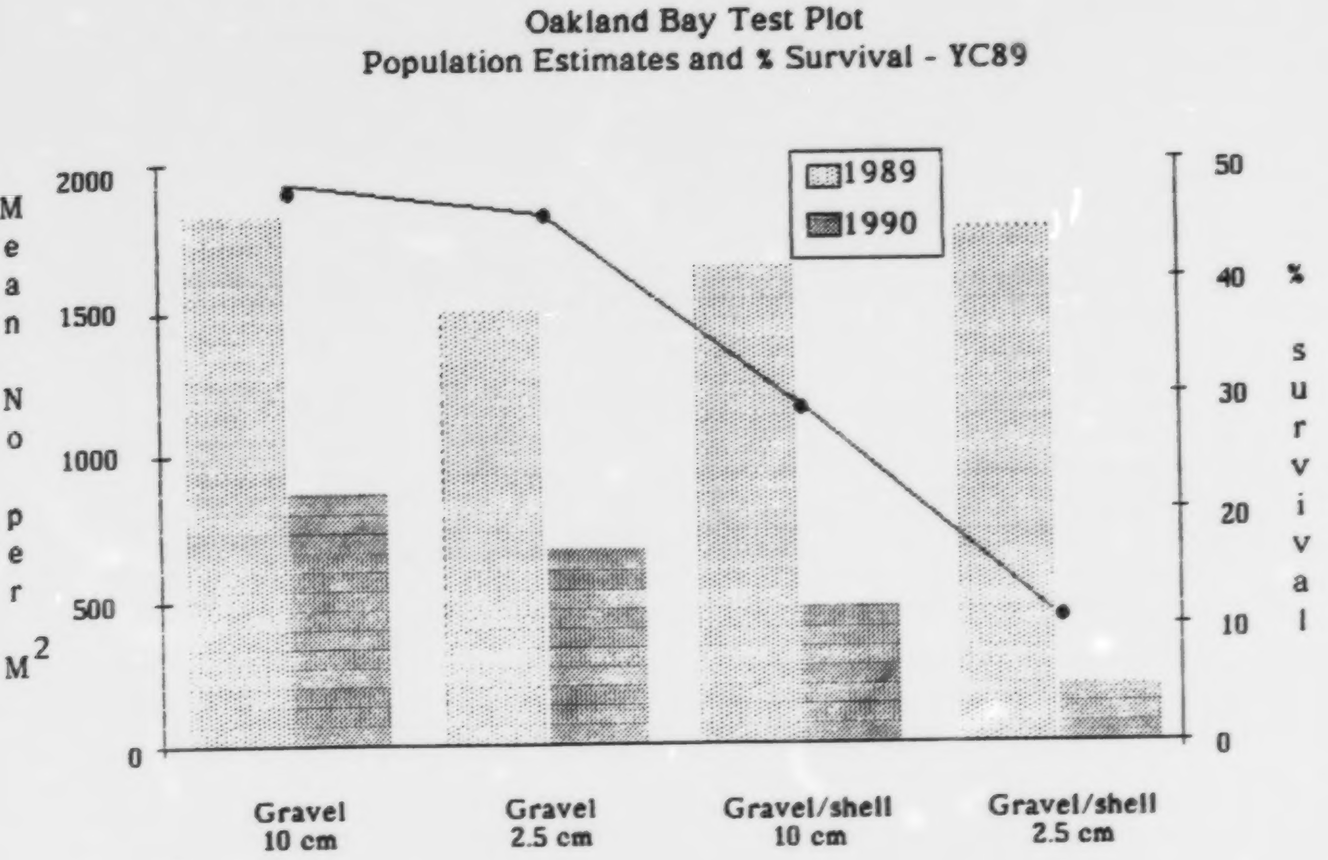
Oakland Bay Test Plot
Population Estimates and % Survival - YC89

Figure 7. Abundance estimates and survival of 1989 year class of Manila clam seed on Oakland Bay test plots. Shaded bars represent population estimates for 1989-90 and the line (.______.) represents the percent survival from 1989 through 1990.

plots had the worst seed survival rates of 28.7% and 11.1% respectively.

These survival rates are exactly opposite from what we expected. We thought the mixed gravel shell plots would show the best survival because of the beneficial effects of shell on recruitment and pH buffering capacity. We also expected both of the 10.0 cm (4.0 inch) thick plots to be slower in becoming productive due to the greater potential infaunal die off and fouling of the substrate. It may be that in Oakland Bay thicker layers can be used before infaunal die off occurs. Possible reasons for the poorer survival on the 50:50 crushed shell gravel plots may be:

1. the crushed oyster shell did not provide the equivalent insulating protection as gravel alone and perhaps frost killed the clam seed;

2. the gravel alone may have provided better protection from

predators; or,

3. the crushed oyster shell may have provided habitat for crabs seeking cover in the shell.

Conclusion

In conclusion the beach gravelling program, by increasing Manila clam production, benefits the State in terms of increased recreational and tribal harvest, improved food production, additional employment and tax revenue. By following the criteria developed for site selection we can minimize any adverse impacts to existing habitat and also ensure successful Manila clam production. The establishment of clam beds will help the State to limit activities which will pollute water and prohibit harvest. In addition to protecting water quality for all Puget Sound residents and users, this will be particularly advantageous to nearby shellfish growers and others who also require high water quality.

Question : What do you use to take your clam samples and how many would you take?

We use a coffee can of about 10 cm in diameter and sample to a depth of 10 cm. We would take thirty samples per plot.

Question : Have you tried clam seeding?

Not yet. We want to try enhancement first because it is cheaper. In those areas without recruitment we will probably seed in the future.

Editor's Note : The 0 foot tide level in Washington State is the mean of the lower low water level while the 0 foot tide level in British Columbia is a level below which the tide rarely falls. As an example, a 0 foot tide in Washington State is approximately a 2 foot tide in British Columbia.

EFFECTS OF DIGGING ON JUVENILE SEEDED MANILA CLAMS

Dr. Neil Bourne

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Nanaimo, British Columbia
V9R 5K6

I have always believed that extensive damage can occur to juvenile clams when intertidal clam beaches are dug more than once per year. However, there are no data to support this contention. Thanks to Mr. Bill Markin and IEC Collaborative Marine Research and Development Ltd. we at the Pacific Biological Station have established an experimental study on Mr. Markin's lease to investigate the effect of repeated digging on juvenile Manila clams.

Four, 6 by 12 meter plots have been established and each plot is subdivided into eight equal plots. Manila clam seed, 6-8 mm in shell length, was marked with fluorescent paint and planted in the plots in June of 1990 at a density of 500 juveniles per square meter.

Half of the plots will be dug once, twice and four times in the first and second years of the experiment. The other half of the plots will be dug once, twice and four times but only in the second year. There are control plots in both years.

At the end of the experiment we hope to have definitive data that will provide accurate estimates of the effect of repeated digging not only on recruits (clams that will enter the fishery within a year) but on pre-recruits (seed clams).

INTERTIDAL CLAM SURVEY IN THE NORTH COAST DISTRICT

Dr. Neil Bourne

Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, British Columbia
V9R 5K6

A survey of intertidal clam resources was undertaken in eight selected areas from Porcher Island to the Bella Bella area during a period of low tides in June 1990.

Butter and littleneck clams were found in abundance on most beaches that were sampled. Only a few Manila clams were found north of Milbanke Sound - Seaforth Channel area. Manila clams were found in abundance on many beaches south of this area in the Bella Bella area.

A Technical Report describing the location of the beaches and the densities, size and growth of clams found on these beaches will be published as quickly as possible. People interested in obtaining further information on these clam resources prior to the publication of the report are asked to contact Dr. Bourne.

CLAM GROW OUT AND HARVESTING TECHNIQUES IN FRANCE

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In the process of establishing a program for development of the shellfish aquaculture industry, the government of France developed a contract with clam and oyster farmers. The contract specified that the State would provide Manila clam seed, monies to control predation and scientific support to monitor the growth and survival of clams. Farmers, in turn, would supply the appropriate amount of labour and supply any necessary equipment. Once the crop was harvested and sold by the farms, the cost of labour is firstly retained by the farmers and the cost of the investment (seed and protection) is returned to the institute and the extra is divided into two equal portions. This has allowed industry growth and ongoing support for industry development.

Our first seeding experiments with Manila clams began in 1975-76 and the first grow out work began in 1980. The hatchery phase is normally one month, the nursery phase two months and between two and six months growth on racks prior to beach planting. Clam seed is put in the substrate at a size of 8-15 mm and is harvested after twenty to thirty months depending on the specific grow out area and the strategy used.

Maximum water temperatures in the major grow out areas vary from 25 degrees C. in the Mediterranean in the south of France, 20-22 degrees C. in the central portion of the country to 16 degrees C. on the northern coast. We carried out growth experiments to determine if warmer water temperatures resulted in faster growth rates. However, we were surprised that the growth rates were virtually the same in all areas.

We also investigated the optimal intertidal location for clam grow out. Brackish waters are suitable for growth, however, we consider summer salinities of 30-38 parts per thousand (p.p.t.) and winter salinities of 25-30 p.p.t. suitable for clam culture. A good grow out area will have some fresh water influence, a sand/mud or gravel substrate, the presence of cockles and polychaetes and between the 1.5 - 2.0 meter tide height. We have been able to catalogue our regions of coastal France by using water temperatures, substrate type, predation and disease concerns. We have produced a map of the coast which colour codes the areas as to their potential.

Disease is one area of concern that will affect the potential of an area. We have had problems in France with Vibrio spp. which affects the calcification of the shell of young and adult clams. The Vibrio bacteria apparently affects the periostricum which produces deformed growth. We have found that sea water aquifers are usually free from bacteria, including Vibrio. To prevent future problems in our hatcheries we plan to concentrate on the use of sea water access through wells. We also have plans to begin disease certification of shellstock, water and seed to prevent future problems with Vibrio.

Our culture potential is also affected by predation. Crabs, specifically the green crab, are one of the most important predators on planted clam seed. We have found that we cannot use nets and rebar, as used in Canada, to keep out the crabs. They just dig under the edge and get under the net. In most farms the crabs are now controlled by constructing a short fence around the total plot perimeter. This fence, covered with net (8-10 mm mesh), tends to keep out crab predators. Plastic bands are hung over the top of the fence to prevent crabs from crawling. Green crabs can crawl along up the net, but it is stopped by a wooden board stapled to the plastic band. This plastic band is made of gutter material. We also use horizontal nets with the edge buried in the sand at a depth of 20-30 cm. In order to prevent predation, we investigated the life cycle of the crab. We found that the 4 cm size is the most dangerous as this crab size can consume clams between 3-15 mm in size. As an adult they can consume clams between 5-35 mm in size but the adult crabs are much easier to control. To prevent the crabs from digging under the net, gravel is placed around the perimeter of the fence. We have determined that if we use gravel size between 8-15 mm the crabs are unable to move it out of the way and are prevented from entering the enclosure.

As a result of this predation and the results of the life cycle studies we now do not outplant clams from our nursery until August/September. Therefore, we do not put our small clams on the beach when the 4 mm juvenile crabs could move through the mesh and eat the clams. By the time the clams are put on the beach in September they are large enough so that juvenile crab cannot eat them. By next March the clams are large enough so that the new year crab progeny cannot move through the net and eat the clams.

We cannot use the mesh size you use here. We have found that crabs will pull seed through the mesh as long as the seed is smaller then the mesh. Therefore we must use 4 mm mesh.

Intertidal culture is controlled by the state and a licence is required to farm on intertidal grounds. However, a number of "ponds" are located on the upland that are private. Water levels in the ponds are controlled some what as many are located at the upper levels of the maximum tidal cycle. The ponds are filled at high tide and the water is retained until the next high tide. Ponds in which the tide exchange occurs only once a month are unsuitable for clam work.

The ponds act as an open air nursery. Water retained in the pond allows the phytoplankton populations to bloom thus creating an optimal food regime for the clam seed. The carrying capacity of such a pond is between 500-700 grams per square meter. Therefore, in order to attain the optimal commercial size (around 20 grams) the maximum grow out density must be less than or equal to 30-40 clams per square meter. This compares to intertidal culture in which a capacity of 200-250 clams per square meter can be achieved.

The pond is seeded by adding 100-150 clams per square meter. The bottom is usually muddy and nets must also be used to prevent predation. The clams are normally harvested between 2-3 cm (5 grams) and reseeded in the pond at a lower density of 30-40 clams per square meter or removed for intertidal grow out.

We have spent some time developing automated systems for laying net. One system uses an agriculture tractor from which the beach net is deployed off of a roll. A "plow like" piece of equipment then buries the edges of the net. We are now working on adding an automated seeding machine to the tractor which will enable us to complete both tasks at once.

In France, through state funding, we have also developed automated harvest technologies. The harvest takes place through a contract between the state and grower. Three types of harvesters have been developed, two using tractors and the other a smaller, rototiller sized machine operated on the beach by the farmer. A substrate made up of approximately 7% gravel between 2-10 mm in size and 46% gravel between 0.5-2 mm in size is required in order to operate a tractor.

Question: Is Manila clam farming in France profitable? And what is either the wholesale or retail price of Manila clams in France?

We have two problems with Manila clam culture in France. One is the disease problem with Vibrio and "Brown Ring". These are manageable and we can deal with this. The other is the increased production from recent wild seed recruitment. Italy has increased its wild harvest which is marketed in Spain, which is also our main market. Therefore, the market price has been reduced as a result of oversupply. We must organize into a national marketing co-operative to deal with this situation. Our farmers, however, do not seem to be interested in co-operatives.

The cost of production is approximately 20-25 Francs per kilo. And the sale price is approximately 30-35 Francs per kilo and perhaps 45 Francs per kilo by the end of the year. It was 50 Francs per kilo two or three years ago. Editors Note : At time of publication, one Franc is worth $0.22 Canadian.

Question : How much clam seed do your hatcheries produce on an annual basis?

Each hatchery produces between 30-100 million but we have too many hatcheries (10). We need 10,000,000 seed to produce 100 tonnes based on 50% survival and a harvest weight of 20 grams. Many farmers want to sell to the Spanish market which would rather have a smaller clam then our current size of 35 mm. They wish to sell at 30-32 mm to fit this market. I believe the state government has just given authorization to change the regulation to waive a legal size requirement for aquaculture production.

Question : What is the effect of machinery on the substrate.

The digging operation aerates the substrate which decreases anaerobic conditions and results, eventually, in increased production.

ESTIMATED COSTS AND RETURNS FOR A CLAM GROW OUT ENTERPRISE

Mr. Peter Gubbels

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The objective of this presentation is to explore the questions: will a cultured clam enterprise pay? and will it provide an adequate return to your investment and to your labour and management efforts?

Dealing with cost and returns for an enterprise which has hardly started is difficult, as there is not much information available. As well, every farm is an entity that has its own biophysical resource base, its specific management capabilities and other variables such as location. In order for us to estimate costs for this presentation we had to make a number of assumptions. Some of the assumptions we have made you may not agree with, but this will give you a basis from which to start. Assumptions can always be changed to fit your particular farm or situation. The major assumptions are:

- the clam farm is a supplementary enterprise in conjunction with an on going oyster operation;
- the species cultured is the Manila Clam;
- the farm location is Vancouver Island;
- the clam farm takes approximately 25% of the operators time and equipment;
- the study is an economic analysis providing annual costs and returns, as of January 1990, for ongoing full production. It takes three years to achieve ongoing production, therefore, we are only dealing with a single year once production begins. In other words it starts in year four;
- the site size is 2 hectares (Ha) with the dimensions 62.5 m x 320 m;
- the tide level is between 1.2 - 2 meters and the substrate is a mixture of sand, mud, gravel and shell;
- the beach is protected from wind and waves, and the water temperature is higher than 13 degrees C. for six months of the year;
- salinity is 24-28 parts per thousand;
- existing population of wild clams is NOT SIGNIFICANT;
- predators unidentified but site is netted for protection;

- the seed is 6-8 mm in size, seeded once a year, every year, between May to July, at a density of 375 per square meter;

- maintenance entails clearing debris, resecuring the predator net, poacher patrol and monitoring;

- 50% loss (linear) over a three year period;

- harvest any time of year except within four months of seeding;

- harvest size at a shell length greater than 38 mm, with an average size of 44 mm. Volume harvested is 188 clams per square meter at 25 clams per pound (7.5 pounds per square meter). Total production 146,000 pounds per year;

- rate of harvest 300 pounds per digger per day;

- the contract rate for harvesting is $0.40 per pound; and,

- clams are marketed directly to a processor.

Based on the above assumptions it was possible to estimate costs and returns for this clam farm. The estimated total investment is $253,490. The estimated total capital investment for clam stock in a single year is about $53,666. Over a three year establishment period this amounts to approximately $202,833, including compound interest.

A summary of estimated annual costs and returns can now be produced. In this example the costs have been broken down: per Ha, per pound and for the whole farm of 2 Ha.

The major costs for this enterprise are the seed and contract harvesting costs. In this analysis the total cash operating cost and depreciation for the 2 Ha site is $119,321. The net farm income is $49,039 and the return to labour and management (for 25% of his time) is $14,219 per 2 Ha or $0.098 per pound.

Given the assumptions and expectations in terms of prices, survival, etc., the operator would be getting 12% return on investment and about $23.00 per hour for operator labour and management.

There are a number of variables and risks, such as survival and price. Therefore, we have analyzed a price range from $0.95 to $1.35 per pound for an annual clam yield from 5.0 to 10.0 pounds per square meter. You can see quite a difference in net farm income per hectare in Figure 8, ranging from a LOSS of $13,301 to a PROFIT of $72,099.

With the present level of clam culture knowledge, differences in management ability and a range in clam prices that might be expected in the future, it is likely that the outcomes for those who attempt to develop clam culture enterprises could vary considerable. The outcomes could range from highly successful businesses to unfortunate business failures. Potential clam growers will need to consider very carefully the opportunity and the risks associated with development of a clam culture enterprise.

Editor's Note: The entire text of this presentation is available in the publication "Estimated Costs and Returns for a Clam Grow-out Enterprise that Supplements an Existing Oyster Farm", by W.G. Roland and P. Gubbels, 1990 from the Ministry Agriculture and Fisheries, Aquaculture and Commercial Fisheries Branch.

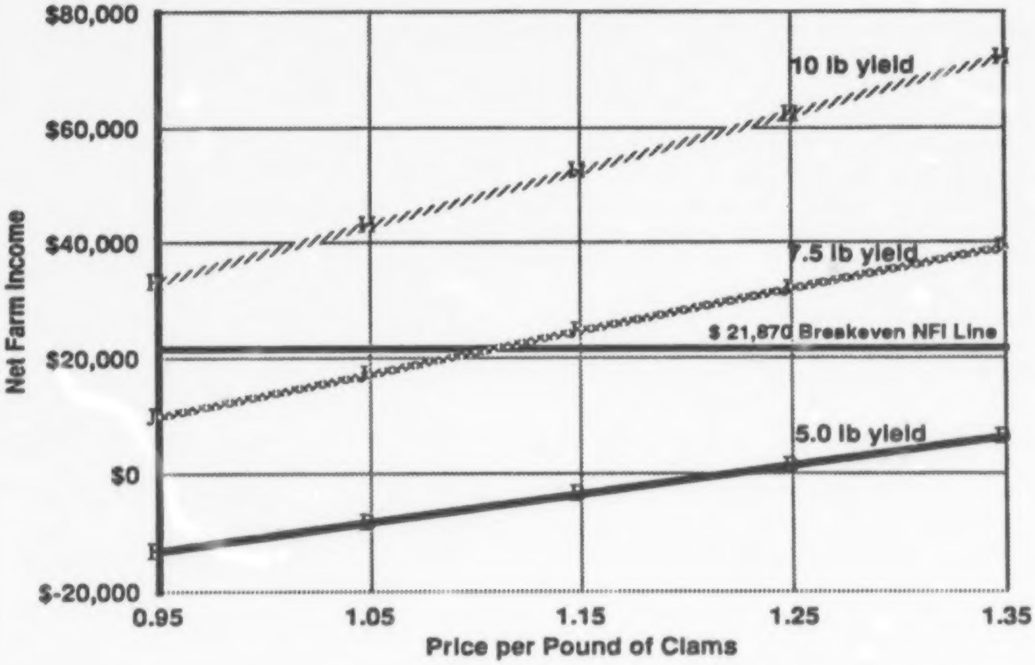

Figure 8. Clam enterprise estimated net farm income per hectare with alternative prices and yields.

MANAGEMENT PRACTICES FOR CLAM CULTURE.

Mr. Paul Taylor

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One of the most important considerations in managing your farm is to "get to know your beach"! I look at a beach and try to identify the problems that I might encounter in trying to grow clams on that particular beach. You should observe your beach in different weather conditions. Look for wind exposure to see if the waves move the substrate. Examine the beach to determine if seasonal streams flow across the area you wish to seed. Also look for strong currents that may reshape the beach.

As predators are a major concern to clam seed survival, look for predators or signs of them. Broken clam shells, for example, indicate crab predation. Moon snails, another predator, are not always found but their signs include countersunk holes in clam shells and egg collars. Ducks, such as scoters, are found in the winter months and can be seen hovering around the beach. Ghost shrimp, while not a predator, degrade the quality of the beach by increased siltation.

Once I have observed the beach, I document the clam growing areas. The beach is divided into small areas, usually along physical barriers, or when there are no physical barriers, divide by size. This size should not exceed two acres. Once the area is established, I measure the square footage and record the approximate tidal height. In May and June I inventory the clams but this can be done at any daylight tide that the beach is exposed.

To sample the beach I make a quadrat box which measures 1 square foot (0.095 meter square). I place the quadrat on the ground and dig the clams found inside the quadrat. Once the clams have been collected I separate out the marketable and near marketable clams and count them. I randomly take between twenty to forty samples from each area. I determine the number of clams per pound, which is usually between 16 to 22, and calculate the total harvestable pounds of clams on the beach.

I do not inventory all of my beaches for submarketable size clam densities but, as I have more seed available from our hatchery, it will become a necessity. To determine sub marketable clam densities I follow the same procedure except that I screen the substrate to find all the small clams. This allows me to maximize densities on the beach. I figure that a maximum density, or carrying capacity, is about 60-80 clams per square foot (Editor's Note: 1 square meter equals 10.8 square feet, thus this density represents 648-864 clams per square meter). At densities higher than this, stunting of the clams occurs.

After I have determined the inventory of market clams I can project how much money will be available during the upcoming year. Often the best return on extra money is investing it back onto the clam ground.

While carrying out the inventory I often notice areas of the beach that would benefit from improvements, such as removing blankets of mussels or the placement of car cover. The cost for me to put car cover out on the beach is $ 2,400 (U.S.) per acre. As an aside, I put lead line around each piece of net by weaving it along the outside edge. This method of attaching lead line is more secure and faster than using electrical ties. The nets are held on the beach through the use of a piece of rebar welded like a "T". I push the "T" in the beach until the top part is flush with the beach. This allows a boat to pick clams off the beach without knocking the rebar "T" over.

If natural sets are not adequate I consider seeding. However, this option is very expensive. (Editors Note: In Washington State the farmer owns the beach, therefore, they are not required to seed the beach and many partake in clam enhancement without seeding.). It costs approximately $10,000 (U.S.) to seed an acre with 6-8 mm clam seed at 60 clams per square foot (648 per square meter) per year . I have found that many areas become over crowded at this rate so I have reduced my seeding rates to 40 clams per square foot (432 per square meter) per year in most cases.

In Oakland Bay, a few years ago, we had an outstanding natural set of Manila clams. At 1 year old they averaged 250 clams per square foot (2,700 per square meter) but by 2 years old they had naturally thinned to 150 clams per square foot (1,620 per square meter). Over the last few months I have been thinning them down to 50-80 per square foot (540-863 per square meter). I am culling out the market size clams and selling them. The undersized clams are moved to another beach that is understocked.

In areas of good recruitment, but poor substrate, I often consider adding gravel to the beach to improve the substrate. I use a styrofoam filled barge powered with an outboard motor and a Wisconsin powered water pump. Gravel is sprayed off of the barge, during high water, using water pressure. I only put 1 inch (2.5 cm) of gravel on the beach at any one time. In some areas this has proved to be very cost effective.

Once the inventory is complete, I determine the order in which the beaches will be dug. To do this I consider the tide level, the ease of digging at night, weather exposure, the size of the clams and the production level needed while digging. The diggers remove all the mature clams. The size of mature clams varies depending on the maximum size clams will attain on that particular beach. In most areas optimal size is reached in three years.

After I have selected the order in which the beaches need to be dug, I dig the whole beach in a systematic fashion to make sure the entire beach is harvested. In areas of high current, I stake the beach so I know where I have already dug.

After the days dig I record the volume of clams that came from the beach. When harvesting is completed in an area I verify my inventory figures. If I came out ahead or behind, adjustments are made. By determining the number of clams I can also determine the number of people needed for digging. By digging on a continual basis I employ people year round, which attracts a better employee. Having long term employees allows me to train them so that they know the operation and the standards that I require of them.

The final step in management of a clam farm is getting a good quality clam to the market place. I traditionally purge the sand from all the clams. Because of theft problems, this step is now left out of many operations. However, to produce the best quality product, I still think this step is essential. I have gone to a submersible float to get away from theft. The clams hold better on a submersible float because of the increased water flow. Also the water is cooler at a depth of 10-15 feet (3-5 meters) than on the surface.

Prior to shipping, the clams are culled. All of the broken clams, rocks and shells are removed. I also sort out the other clam species to make sure the customer gets only the species desired. The clams are moved to the plant and run through a large rotary drum which sizes the clams prior to final inspection before market. The clams are packed for air or truck freight. All packages must be tagged. I can trace a shipment back to the exact bed from which they were harvested, the identity of the digger and the date dug.

Digging on a year round basis allows me to establish markets that order consistently. When there are gluts of clams on the market, due to wild clam landings, my markets stay with me as they are use to the consistency and quality of our product. It also allows me to obtain the top dollar for my product.

DEPURATION OF SHELLFISH IN BRITISH COLUMBIA

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The manual that is encapsulated in my talk on shellfish depuration was funded by the Aquaculture and Commercial Branch of the Ministry of Agriculture and Fisheries (M.A.F.) through the B.C. Oyster Grower's Association and will be made available within the next few weeks by M.A.F. A great deal of the information was provided by Mr. Roger Dunlop, who had experience in setting up a depuration plant in Sooke Harbour. Mr. Robert Gunn was involved as an economic consultant, Mr. Bob Baden as an industrial liaison, Mr. Glen Gibbard was involved in making comments on the engineering aspects of the manual and its proposals, Mr. Box Cox was the M.A.F. representative and Mr. Wayne Holmes of the Department of Fisheries and Oceans (D.F.O.), Fisheries Inspection Branch, provided critical comments on this manual.

I will spend little time discussing the manual and more time on the issues that depuration raises. Depuration can be defined as "the removal of coliform bacteria from living bivalve shellfish". The regulations that govern depuration very clearly state this. Anyone that is contemplating the process of depuration must consider it only in the context of the removal of coliform bacteria and not other contaminants.

A basic depuration system (Figure 9) contains: a water intake; a pump; a sediment trap where sand and heavy material settle out; a sand filter to remove larger organic materials; a header tank to provide water storage and even flow in terms of pressure and flow rate through the system; a water sterilization system; a monitoring system to control, measure and record water flow; and, depuration tanks for product treatment. The system may also have to provide for waste water treatment prior to disposal.

The intake point should be located so that you are accessing clean water for the depuration system. The water should be void of all known contaminants.

If the intake water is particularly rich in nutrients, such as nitrates and phosphates, you may require the installation of a biofilter in between the sand filter and the header tank. A biofilter allows the regulated growth of "friendly" bacteria which will render the removal of high levels of nutrient components.

The water sterilization system is required to safeguard the depuration process. The most popular method for achieving sterilization is through the use of ultraviolet (U.V.) light. Historically, chlorine has been used worldwide. However, as it is toxic to shellfish, chlorine must be detoxified prior to pumping into the depuration tanks. Ozone, which is used in Europe, is recognized in North America as a food additive, rather than a process and, therefore, is not allowed to be used in the depuration process.

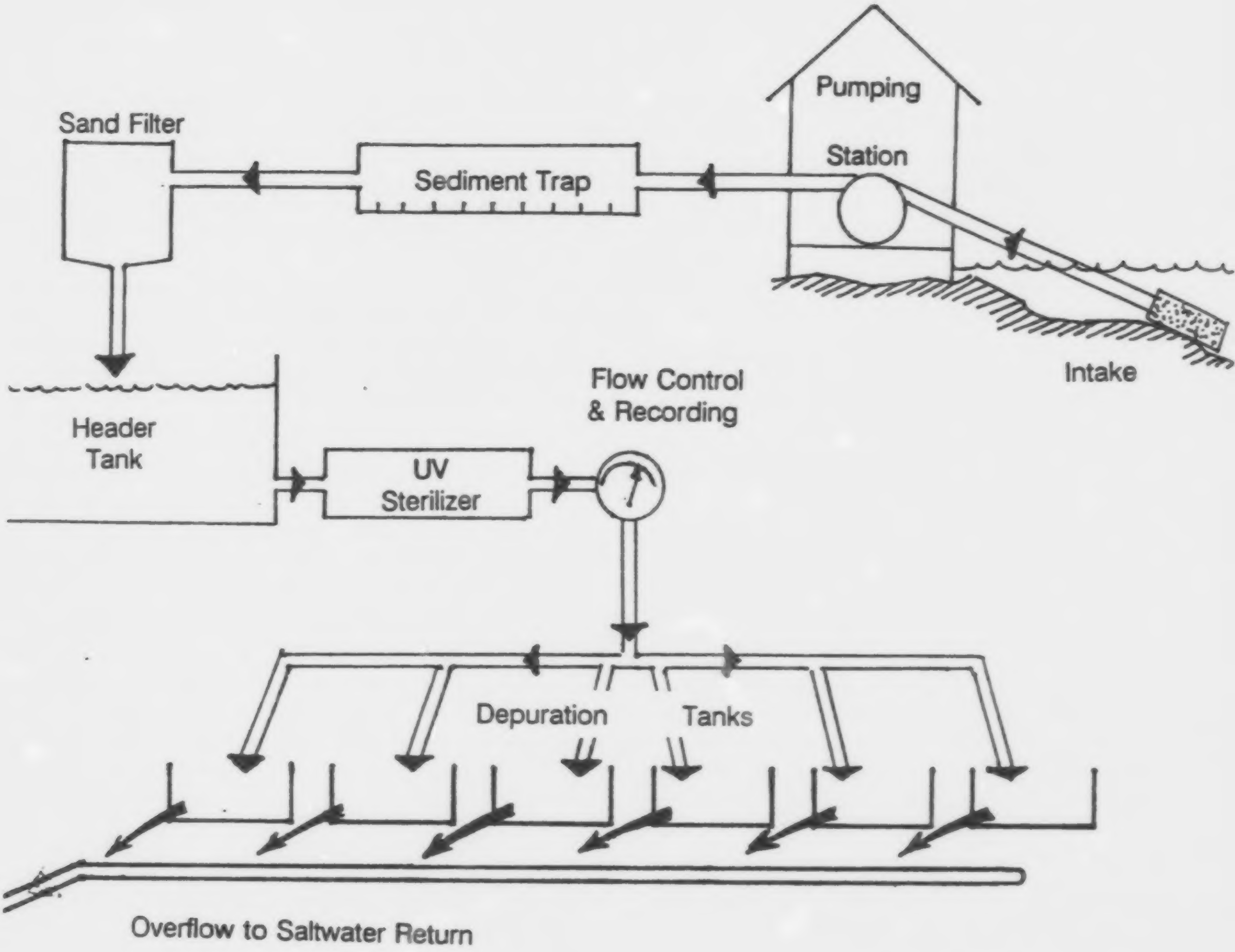

Pumping
Station
Sand Filter
Sediment Trap
Intake
Flow Control
& Recording
Header
Tank
UV
Sterilizer
Depuration
Tanks
Overflow to Saltwater Return

Figure 9. A basic flow-through depuration system

The recording and measurement of flow rates is extremely important so that the history of any given depuration run may be documented. This will allow any problems to be tracked to its source such as cessation of flow or alterations in flow patterns.

Table 6 illustrates a flow chart of draft Fisheries regulations for depuration. Shellfish with a most probable number (M.P.N.) coliform count of greater than, or equal to, 2,300 M.P.N. per 100 grams are not allowed, by regulation, to be depurated. Animals under this number are required to depurated for 48 hours, in two 24 hour periods. Midway through the process, i.e. hour 24, the water is drained, the tanks and shellstock are cleaned and the process is continued for another 24 hours. Samples of shellfish are retained at 24 and 48 hour intervals, and are submitted for analysis. Those animals which meet the criteria of less than, or equal to, 170 M.P.N. per 100 grams are released for sale. Those animals that do not pass the test may be returned to the beach or reprocessed through the system again.

The manual that we prepared involved the development of design guidelines for different sizes of plants. The plant designs are based on a manual produced by the Spinney Creek Oyster Company of Maine. Plant design is modular, which allows the expansion of capacity to meet volume requirements.

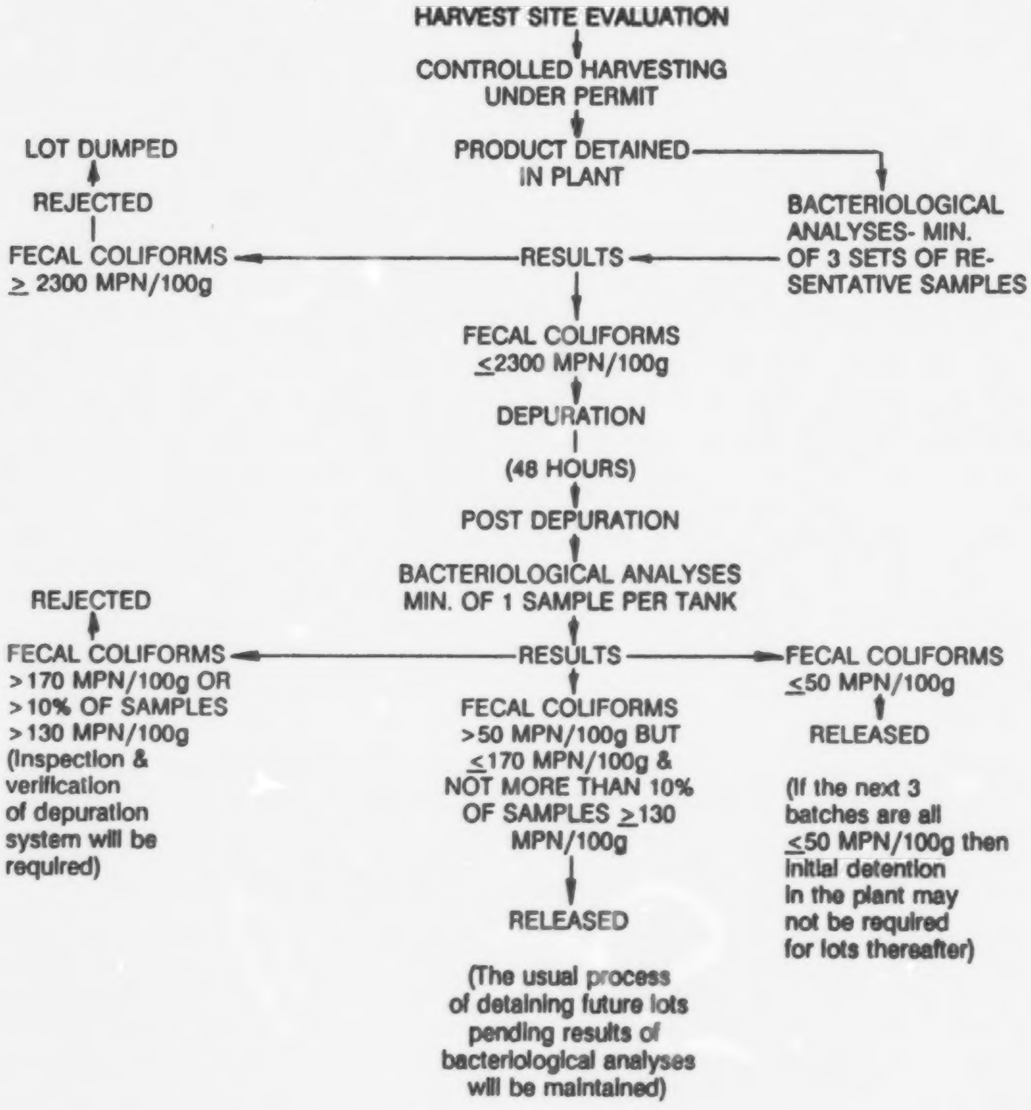
A major component of the plant design is the storage area for product. Incoming and outgoing product must be separate so as not to chance cross contamination of product. In addition, as the product must be cleaned at 24 hour intervals, you must have a location to put the product that is free from contamination while cleaning takes place. I should point out that a depuration facility must have a Processing Plant Licence and that all the design criteria, drawings and engineering specifications must be cleared by D.F.O. prior to construction.

Current fisheries regulation permits you to process only one "Lot" of shellfish through a facility at any one time. A "Lot" is defined as a specified quantity dug by a specific digger, on a specified day, from a specified lease. This requirement will dictate the capacity of the plant and the extent to which you operate.

Based on the modular system, we have estimated what it would cost to depurate Manila clams in British Columbia. For these estimations we assumed that the plant is a free standing facility in which one batch is processed at one time. The cost for depuration, based on the largest facility in the manual, was $0.11 per pound (Table 7).

It is important to recognize that there are a substantial number of other contaminants with which we should be concerned and to acknowledge that depuration regulations only deal with coliform bacteria. It may be more prudent for us to spend our efforts keeping our water clean rather than developing a number of depuration facilities which can only handle one of the many contaminants.

Table 6. Department of Fisheries and Oceans inspection summary of shellfish sampling for depuration.


HARVEST SITE EVALUATION
CONTROLLED HARVESTING UNDER PERMIT
LOT DUMPED
PRODUCT DETAINED IN PLANT
REJECTED
BACTERIOLOGICAL ANALYSES- MIN. OF 3 SETS OF RE-SENTATIVE SAMPLES
FECAL COLIFORMS ≥ 2300 MPN/100g
RESULTS
FECAL COLIFORMS ≤2300 MPN/100g
DEPURATION
(48 HOURS)
POST DEPURATION
BACTERIOLOGICAL ANALYSES MIN. OF 1 SAMPLE PER TANK
REJECTED
FECAL COLIFORMS >170 MPN/100g OR >10% OF SAMPLES >130 MPN/100g
RESULTS
FECAL COLIFORMS ≤50 MPN/100g
FECAL COLIFORMS >50 MPN/100g BUT ≤170 MPN/100g & NOT MORE THAN 10% OF SAMPLES ≥130 MPN/100g
RELEASED
(Inspection & verification of depuration system will be required)
(If the next 3 batches are all ≤50 MPN/100g then initial detention in the plant may not be required for lots thereafter)
RELEASED
(The usual process of detaining future lots pending results of bacteriological analyses will be maintained)

1. Revised from the DFO Fish Inspection Regulations, Appendix A.

Table 7. Extended operating costs of multiple module formats.

MODULAR SIZE	CAPACITY lbs/yr[1]	LABOUR Manag.	Gen.	Micro.	MAIN. & REPAIR[2]	SERVICES (hydro etc)	LAB. SUP.	BANK PAY.[3]	TOTAL COST	COST PER POUND ($)
1	400,000	30,000	15,000	20,000[4]	3,000	2,000	N/A	24,000	89,000	0.22
2	800,000	35,000	30,000	30,000	6,000	4,000	3,000	36,000	134,000	0.17
4	1,600,000	40,000	60,000	35,000	12,000	8,000	6,000	60,000	201,000	0.13
6	2,400,000	45,000	90,000	35,000	18,000	12,000	9,000	96,000	275,000	0.11

1. Based on a 40 week operating year and the Manila clam as the species being depurated.

2. Includes contingency allowances.

3. Estimated on the basis of a 25 year mortgage in which the total payout is 3 times the amount borrowed. It is assumed that the entire capital cost of the facility is borrowed.

4. This is an allowance for coliform analyses by private labs rather than for on-site personel.

MARKETING OF CLAMS IN BRITISH COLUMBIA

Mr. Gordon McClellan

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The word marketing has a literal translation of "an aggregate of functions involved in moving goods from producer to consumer".

Although sales are sometimes viewed as a unique function of business, the elements of success in marketing in the shellfish industry must be viewed some what differently. Marketing begins on the beach and ends with the consumer. A good marketing program has to start with the farmer. If the farmer does not take care of his product it does not matter what the marketer does with it because it will not sell.

With respect to the clam market we must know how many clams are currently in the market and with the advent of clam farming, how many will be in the market by 1995. Personally, I feel that clam farmers in B.C. will have two competitors, the B.C. wild fishery and the Washington State clam fishery. With current management practices of the wild fishery we may see a small increase in production of about 1-2 million pounds by 1995. Through discussion with Washington State farmers, I have found out that they feel they will have an additional 100 acres in production by 1995. Therefore, we must add another 2 million pounds to our 1995 production.

If B.C. clam farmers culture 15% of their current acreage (300 acres) by 1995, their production will increase by another 7-9 million pounds. The total result will be an additional 10-13 million pounds of clams available for market by 1995. With that much of an increase in clam production, combined with a more consistent supply from the farms, the price of clams will undoubtable drop.

In order to keep the price at a reasonable level we must, by 1993-94, have a quality assurance program in place, and we must access new , nontraditional markets. While I am not sure we will be able to penetrate the European market without drastically lowering our prices, I suspect we will be able to capture some of the major East Coast markets. However, this will still require a price cut of perhaps 20%.

I believe a product development and product quality program should be put in place by the industry in order to be prepared for 1995 and our potential increase in Manila clam production.

PANEL DISCUSSION

Mr. Lorne Clayton IEC Collaborative Marine Research and
Development Ltd.
Moderator

Question : How much can a clam digger harvest in one tide and how long can you keep your clams in wet storage?

Mr. Paul Taylor : Taylor United Inc.

My average digger probably harvests about 300 pounds a tide. The holding time on a submersible float depends somewhat on the time of the year. In the summer, for example, I would not hold them over five days. However, in the winter I could hold them two weeks.

Question : What do you see market prices doing in the next while?

Mr. Paul Taylor : Taylor United Inc.

If the market is supplied with good quality product on a consistent basis, I personally think there is a lot of market out there at today's prices. We keep edging our price up. The customers get more irate if we don't have the volume they want, rather than about the price.

Question : What is the impact of the New Zealand cockle imports on Manila clam sales?

Mr. Paul Taylor : Taylor United Inc.

They are a substitute product. People prefer the Manila clam if they can get them. I don't think it has affected my sales to any extent.

Mr. Gordon McClellan : Mac's Oysters Ltd.

I think we have to be more competitive than the New Zealand cockle which is making inroads into some of the wholesalers I deal with. If we are not more competitive, we will loose markets to the cockle. Most consumers do not know the difference between a Manila clam and a cockle.

Question : The regulations established for clam farming in B.C. are based on the availability of clam seed. If, for example, 50 acres of beach were seeded at a density of 200 per square meter there would be a requirement for 40,000,000 clam seed. There is only one hatchery in B.C. capable of producing clam seed and it is currently tied up with scallop work. The current regulations, therefore, are based on product that is not available in B.C. For the foreseeable future this volume will not come out of B.C. This means it will have to come from out of country, most likely the US. I would like to know where our supply of clam seed is coming from?

Mr. Bill Roland : Ministry of Agriculture and Fisheries (M.A.F.)

We did a survey of most hatcheries and you are right. Most seed would come from the US and the hatcheries supplying the seed would like about one years lead time. They could produce clam seed in the order of the numbers you have mentioned.

Question : Interruptions in this years fishery harvest have resulted in a "product hole". What effect did this have on the market?

Mr. Gordon McClellan : Mac's Oysters Ltd.

The worst thing that can happen to you is to have a hole in production. Most people have felt a softening of the market. It is easier to build on an existing market rather than start a new market. This is why I hope the wild fishery will provide the bulk of our clams until clam farms are up and running.

Question : What do you think the price will come down to?

Mr. Gordon McClellan : Mac's Oysters Ltd.

I suspect a 20% drop in prices.

Comment: Mr. Bill Dewey : Past President of the Pacific Coast Oyster Growers Association (P.C.O.G.A.)

The P.C.O.G.A. looks on depuration with caution because many people consider is as an alternative to clean water. We make that clear to everyone... DEPURATION IS NOT AN ALTERNATIVE TO CLEAN WATER.

APPENDIX I

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